Desert Research Institute

Humboldt River Basin Water Authority

Data Gap Analysis

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1. Introduction

This study's objective was to identify gaps in data and knowledge regarding water quantity and quality in the Humboldt River Basin (Figure 1) and to provide recommendations regarding priorities for future studies. The Nevada Sate Engineer requires information regarding the basin's available water resources and existing allocations and use. Likewise, the Nevada Division of Environmental Protection (NDEP) requires information about intended beneficial uses and the impacts of existing or proposed activities on those intended uses. To assist the State Engineer and NDEP in making decisions about water management, it is important that the information required be readily available and scientifically sound. Based on meetings with State Engineer and NDEP staff, we developed an inventory of data requirements of both agencies in their decision making process. We then conducted a thorough review of existing data sources and reports for both water quantity and quality in the basin. Readily available data and reports were compiled into a project database. A data gap analysis was then performed by comparing data requirements with available data. The major gaps in data were identified as priorities for future monitoring. The following report provides the details of the gap analysis and recommendations for future monitoring. The report has been segmented into two parts: 1) water quantity data for the Nevada State Engineer's office, and 2) water quantity data for the NDEP.

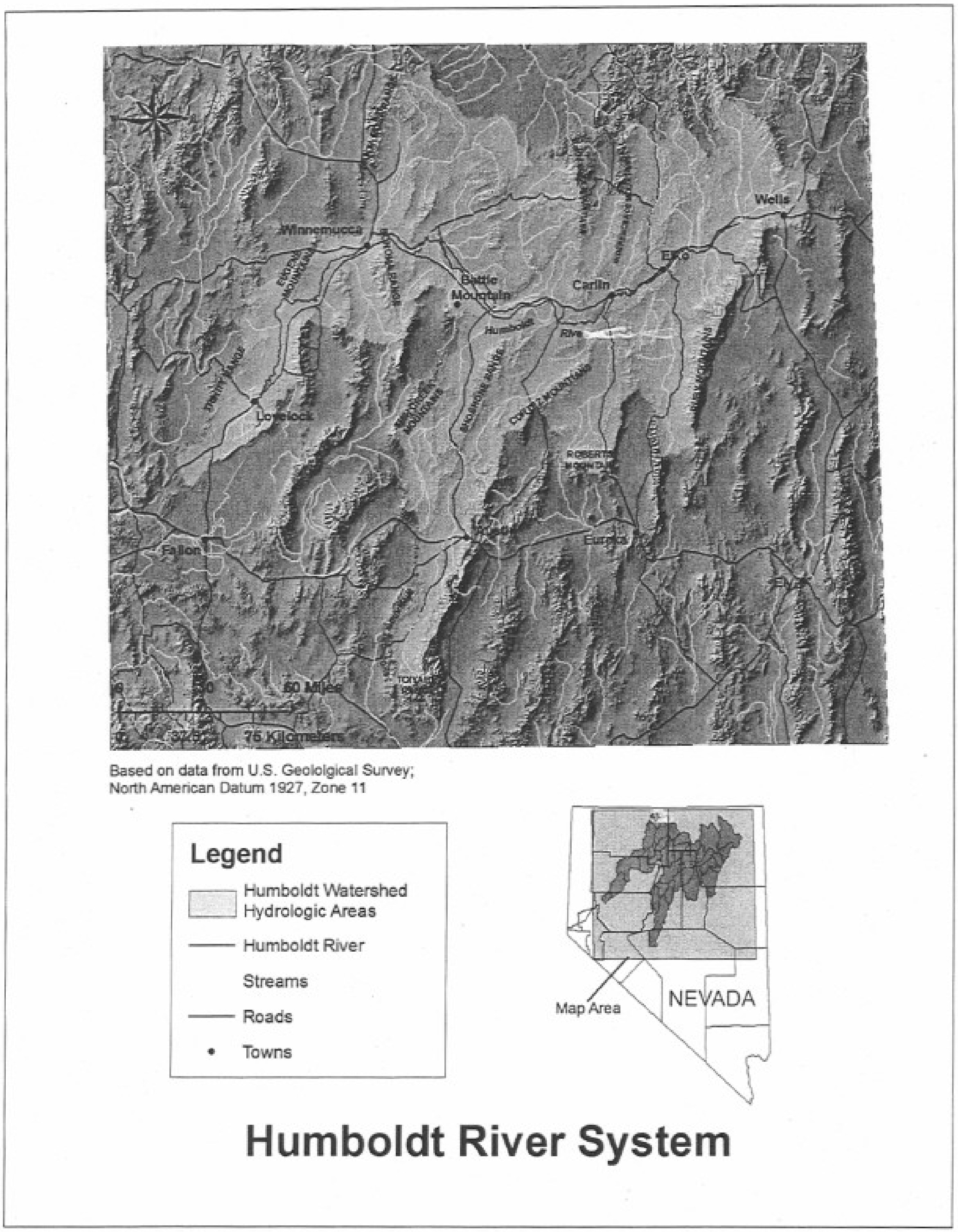

Figure 1 Humboldt River Basin

2. Water Quantity Data

The purpose of this report is to describe the data requirements of the Nevada State Engineer in the process of distributing water rights and to describe the availability of such data in the Humboldt River Basin. This report also provides recommendations for future data collection activities in order to address shortcomings in existing datasets. Where available, the data described within this report has been obtained and integrated into a database.

The Nevada State Engineer's primary responsibilities are focused on appropriation of public waters and ensuring the use of the public's water in a variety of beneficial uses. With respect to data requirements, the State Engineer is interested in data that can support development of a water budget for the Humboldt River Basin and subbasins. The State Engineer attempts to account for all water entering, leaving, and staying in the basin. Data that supports his decisions include:

- Evaporation
- Transpiration
- Precipitation
- Inter-basin transfer
- Consumptive use
- Irrigation for crops and livestock
- Groundwater storage
- Surface water entering and leaving the basin
- Municipal use

Quantification of these components is essential to developing an appropriate water budget, and accurate measurements and estimates are essential. However, adequate data to describe these components is often unavailable. For example, the State Engineer has extensive data describing water right permits in the Humboldt River Basin, but actual consumptive use is rarely measured. Based on a thorough review of available data describing water status in the basin (detailed below), the following recommendations have been made as research priorities:

- Improved estimates of ET are essential. We suggest a combination of direct field measurements, analyses from meteorological data, and remote sensing techniques to better describe basin wide ET. Additional evaporation estimates would also be useful.
- Consumptive water use must be better described. A substantial knowledge gap exists between allocated water rights and actual consumptive use. We recommend an investigation of actual water use including the ET study mentioned above and improved quantification of reuse water (i.e. from mine dewatering).
- Groundwater level data can be monitored easily and inexpensively by instrumenting a larger portion of the several thousand monitoring wells in the basin. We also suggest expanding the Great Basin Regional MODFLOW model to encompass the entire Humboldt River Basin.
- Improved precipitation estimates could be made by analyzing NEXRAD data and adding weather stations in regions of the basin where data is sparse.

- Paper copies of reservoir storage volumes and discharge should be transferred to a digital database. Automated equipment should be installed to monitor these parameters.

2.1. Evapotranspiration and Evaporation

2.1.1 Descriptions of Available Reports and Data

Up to 90% of the total precipitation in the Humboldt River Basin is believed to be lost to evapotranspiration (ET) (Eakin and Lamke 1966). A portion of the precipitation is lost immediately to ET and the rest is lost after being stored as snow or soil moisture. The other 10% of the total precipitation in the basin becomes runoff or groundwater and much of it is still eventually lost to ET. Thus, it is essential to know details of evapotranspiration processes in the Humboldt River basin.

There are two readily available studies on ET in the Humboldt River Basin. The Water Conservation Field Services Program (WCFSP), under the Bureau of Reclamation, provided ET data to local growers to improve irrigation scheduling to meet crop irrigation needs. The report from WCFSP (2000) summarized the use of ET data. The number of data points, duration of data collection, and availability of ET data is not clear in the report. Also, Shevenell (1996) conducted a study to estimate potential evapotranspiration statewide in Nevada. The author collected data in 1994 from 124 weather stations throughout Nevada and used the information to estimate ET. The collected data and its implications are discussed in the document. However, it appears that very few direct measurements of ET have been collected within the basin. Further, even fewer studies of evaporation have been conducted in the basin. The only evaporation study we were able to find was the masters study by Chen (1978). Chen estimated that annual evaporation in the basin is 42 to 60 inches.

In spite of the lack of ET measurements in the basin, ET can be estimated using meteorological and land use data. The meteorological data can be used to estimate potential ET and the land use data can be used to determine coefficients for estimating actual ET. Several empirical methods have been developed for estimating ET from measurements of relative humidity, temperature, wind speed, and solar radiation (e.g. Penman-Monteith and Blaney-Criddle). To investigate the possibility of estimating ET using weather data, we identified weather stations located in the Humboldt River Basin containing the data required to apply these techniques. The National Weather Service has a weather station at the Elko airport, which collects weather data including minimum/ maximum temperature, dew point, atmospheric pressure, and wind speed on an hourly basis. Real time data as well as archived data are readily available online (http://weather.noaa.gov/weather/current/KEKO.html).

The National Weather Service also collects measurements of precipitation and minimal/ maximum temperature through the Cooperative Observer Sites (Coop: http://www.nws.noaa.gov/om/coop/index.htm). Seven Coop weather stations are located in the Humboldt River basin. Historical data for the Coop stations were obtained from the Western Regional Climate Center and incorporated into the GIS database. The spatial distribution of the Coop weather stations is shown in Figure 2. Table 1contains a list of the stations in the basin.

Table 1 Summary of Coop stations in the Humboldt River Basin

Station Names	Latitude	Longitude
Elko Airport	40.8333	-115.783
Dixie Valley Stark	39.7167	-118.183
Dixie Valley Boyer	39.9500	-117.867
Carlin Gold Mine	40.9667	-116.317
Palisades	40.6000	-116.2
Rand Ranch Palisades	40.4333	-116.117
Battle Mountain	40.6500	-116.933
Battle Mountain FAA	40.6167	-116.867
Paradise Valley Ranch	42.1667	-117.533
Paradise Valley	42.1833	-117.417
Imlay	40.6667	-118.15
Rye Patch Dam	40.4667	-118.3
Lovelock	40.1833	-118.467
Lovelock FAA	40.0667	-118.55

Another climate data source in the basin is the Remote Automatic Weather Stations (RAWS), managed by the U.S. Forest Service and Bureau of Land Management and monitored by the National Interagency Fire Center. RAWS are mainly located in remote areas, especially in national forests (unlike systems operated by the National Weather Service, in which stations are located at airports). Collected data is stored at the National Interagency Fire Center in Boise, Idaho, (http://www.fs.fed.us/raws/). In the Humboldt River Basin, there are 4 stations within the basin and 7 in the surrounding area (Figure 2). Weather data such as wind speed, precipitation, barometric pressure, and soil moisture are collected from these stations. Table 2summarizes RAWS station numbers, their exact locations, and the website addresses where data is accessible to the public. The RAWS station locations were added to the GIS database with hyperlinks to the online data.

Table 2 Summary of RAWS station information

Station #	Station Names	Latitude	Longitude	URL for data
1	Alligator Ridge	39.73	-115.65	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNALL
2	Antelope Lake	41.68	-116.76	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNANT
5	Bailey Ranch	40.44	-116.17	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNBAI
15	Blue Wing	40.33	-119.09	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNBLU
24	Burma Spring	41.19	-117.40	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNBUR
33	Coils Creek	39.83	-116.49	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNCOI
35	Coyote Canyon	40.49	-118.11	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNCYC
41	Desatoya	39.30	-117.58	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNDES
88	Palisade	40.62	-116.23	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNPAL
97	Red Butte	39.98	-117.32	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNREB
104	Siard	40.39	-117.62	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?nvNSIA

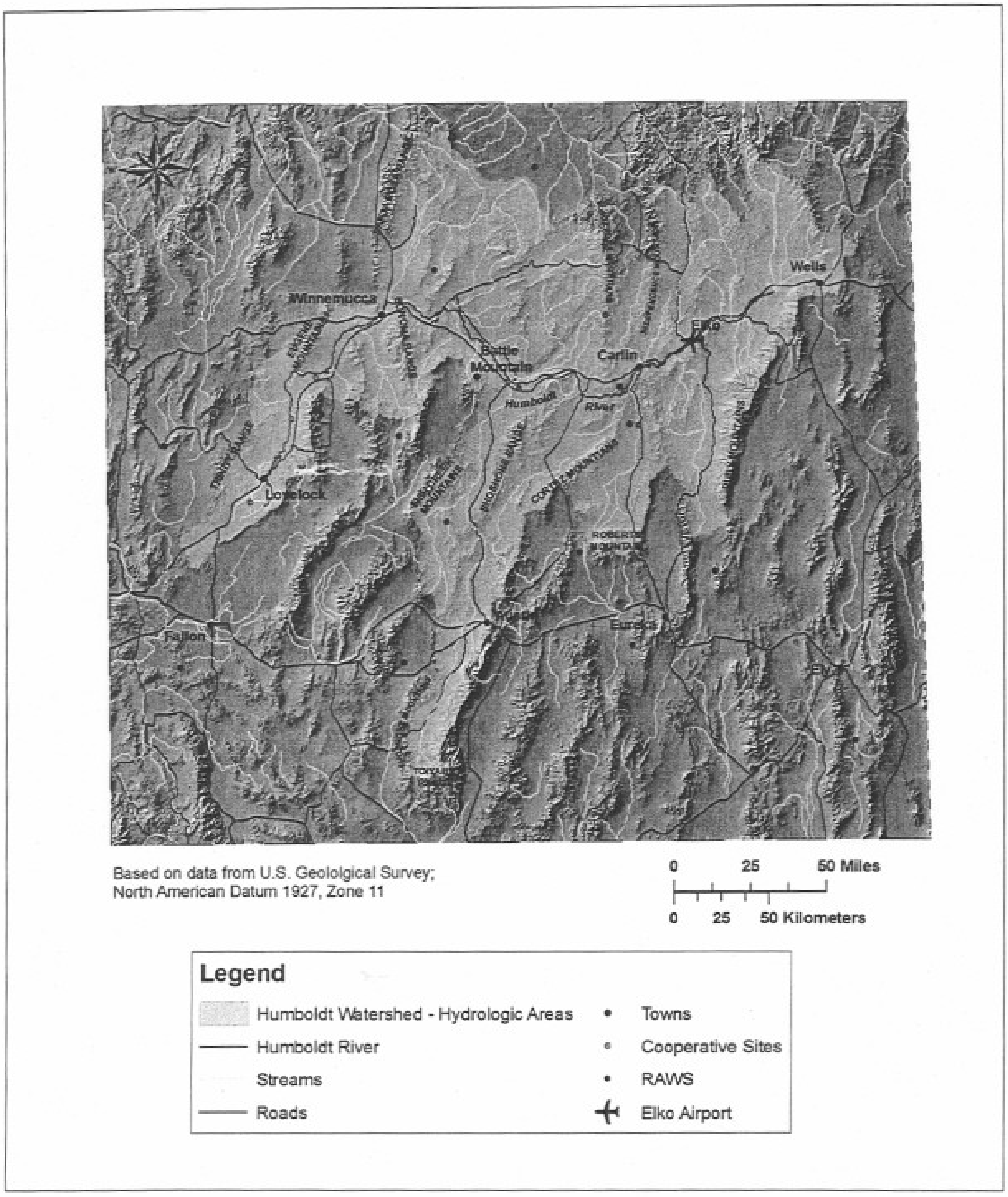

Figure 2 Data collection sites for the NWS, Coop, and RAWS

In addition to direct measurements and weather based techniques, ET can also be estimated using remote sensing techniques. These methods utilize satellite sensors that can detect wavelengths of light outside of the visible light spectrum. Multiple satellites are available for use at varying resolutions. Fine resolution satellites include IKONOS, IRS and Landsat while satellites of coarse resolution include MERIS, SPOT, AVHRR and the Earth Observing System's Aqua and Terra satellites. We have verified both MODIS and TM data availability for the Humboldt River Basin for a range of spatial and temporal resolutions. MODIS data is freely available from NASA (http://edcimswww.cr.usgs.gov/pub/imswelcome/). Landsat and other high-resolution data are available for purchase from several distributors.

2.1.2 Additional Data Needs for the Nevada State Engineer

Actual ET in the Humboldt River Basin is very poorly quantified. The State Engineer's office has identified ET has a major data gap in the region. Although the amount of water permitted for consumptive use in the basin is well documented, the volume of water actually applied, and the percentage of that water lost through ET is estimated through crude techniques. Based on the procedures followed at previous hearings conducted by the Nevada State Engineer, additional data is needed in order to prepare for future water rights decisions in the Humboldt River Basin. For example, McCurdy (2004) examined potential evapotranspiration (PET) from meteorological station data in Eastern Nevada, and the report was used in the recent NSE hearing for the Southern Nevada Water Authorities water rights application in Spring Valley. The author used data from RAWS and Coop sites to calculate PET. Several other studies have been conducted in the Spring Valley hearing utilizing direct ET measurements and remote sensing techniques.

2.1.3 Recommended Data Collection Activities

Obtaining accurate ET information is crucial to better understand the water balance of the Humboldt River Basin. As this is the primary mechanism for water consumption in the basin, and ET is poorly quantified, it is recommended that this be a priority of future studies on water quantity in the basin. We recommend studying basin ET using a combination of direct ET measurements (Bowen Ration or Eddy Flux towers), weather based techniques, and remote sensing. The direct measurements should cover a broad range of land use types with a focus on cover types that use large amounts of water (i.e. irrigated fields). The direct measurements can be used to improve empirical relationships for estimating ET from weather stations and remote sensing techniques. An excellent approach for estimating large scale ET is the Lower Colorado River Accounting System (LCRAS) used by the Bureau of Reclamation. DRI researchers are also engaged in research on the Lower Colorado River to estimate ET directly from remote sensing data in the absence of direct ET measurements.

2.2. Precipitation

2.2.1 Description of Available Reports and Data

An estimated total average annual precipitation in the Humboldt River basin is 700,000 acre-feet. Most of the annual precipitation occurs in the winter, and about 70% of it occurs from December to May. Most of such precipitation takes the form of snow, thus it tends to accumulate and supply the spring runoff (Eakin, Moore, & Everett, 1965). Mean annual precipitation in the Humboldt River basin varies depending on the altitude. For example, from 1950 to 1999 the mean annual precipitation ranged from 13.17 inches (Austin) to 16.12 inches (Lamoille) at weather stations at or above 6,000 ft while it ranged from 8.06 inches

(Battle Mountain) to 9.63 inches (Elko) at weather stations at altitude between 4,300 ft and 5,100 ft (Figure 3).

Weather data, including precipitation, has been observed at 7 stations in the Humboldt River Basin through the National Weather Service Coop sites. The data for these stations is maintained and distributed by the Western Regional Climate Center (WRCC). The data was requested from the WRCC and incorporated into the project database (see Table 1). Further, an automated weather station is maintained by the National Weather Service Telecommunication Operations Center at the Elko Regional Airport. In addition to precipitation and temperature data, the Elko station observes dew point, atmospheric pressure, and wind speed on an hourly basis. The WRCC also provides a number of reports describing precipitation data and trends in the region. The WRCC official website summarizes relevant information at state level including climate, wind, evaporation, and amount of sky cover (for the detailed information, please visit http://www.wrcc.dri.edu/CLIMATEDATA.html).

As described in Section 2.1, weather data is also colleted at RAWS stations. In the Humboldt River Basin, there are 4 RAWS stations and 7 adjacent stations. Weather data such as wind speed, precipitation, barometric pressure, and soil moisture are collected from these stations (see Table 2).

Another source of precipitation data is from the Oregon State University PRISM Group. Its official website provides climate data sets created by the PRISM climate mapping system (http://www.ocs.oregonstate.edu/prism). These data sets have been developed through projects funded partly by the USDA Natural Resources Conservation Service, USDA Forest Service, NOAA Office of Global Programs, and others. The data sets were created using the PRISM climate mapping system, developed by Dr. Christopher Daly at Oregon State University. PRISM is unique in that it incorporates a spatial climate knowledge base that accounts for rain shadows, temperature inversions, coastal effects, and more in the climate mapping process. The long-term precipitation pattern for the Humboldt River Basin as determined by PRISM is shown in Figure 3.

A final source of precipitation data in the basin is from the Snowpack Telemetry (SNOTEL) stations operate by the Natural Resources Conservation Service (NRCS). The NRCS installs, operates, and maintains this system to collect snowpack and related climatic data in the Western United States. Nine SNOTEL stations are located within or near the Humboldt River Basin. The stations report snow depth, snow water equivalent, and precipitation. Current and historic data for the Nevada SNOTEL stations is available online at: http://www.wcc.nrcs.usda.gov/snotel/Nevada/nevada.html

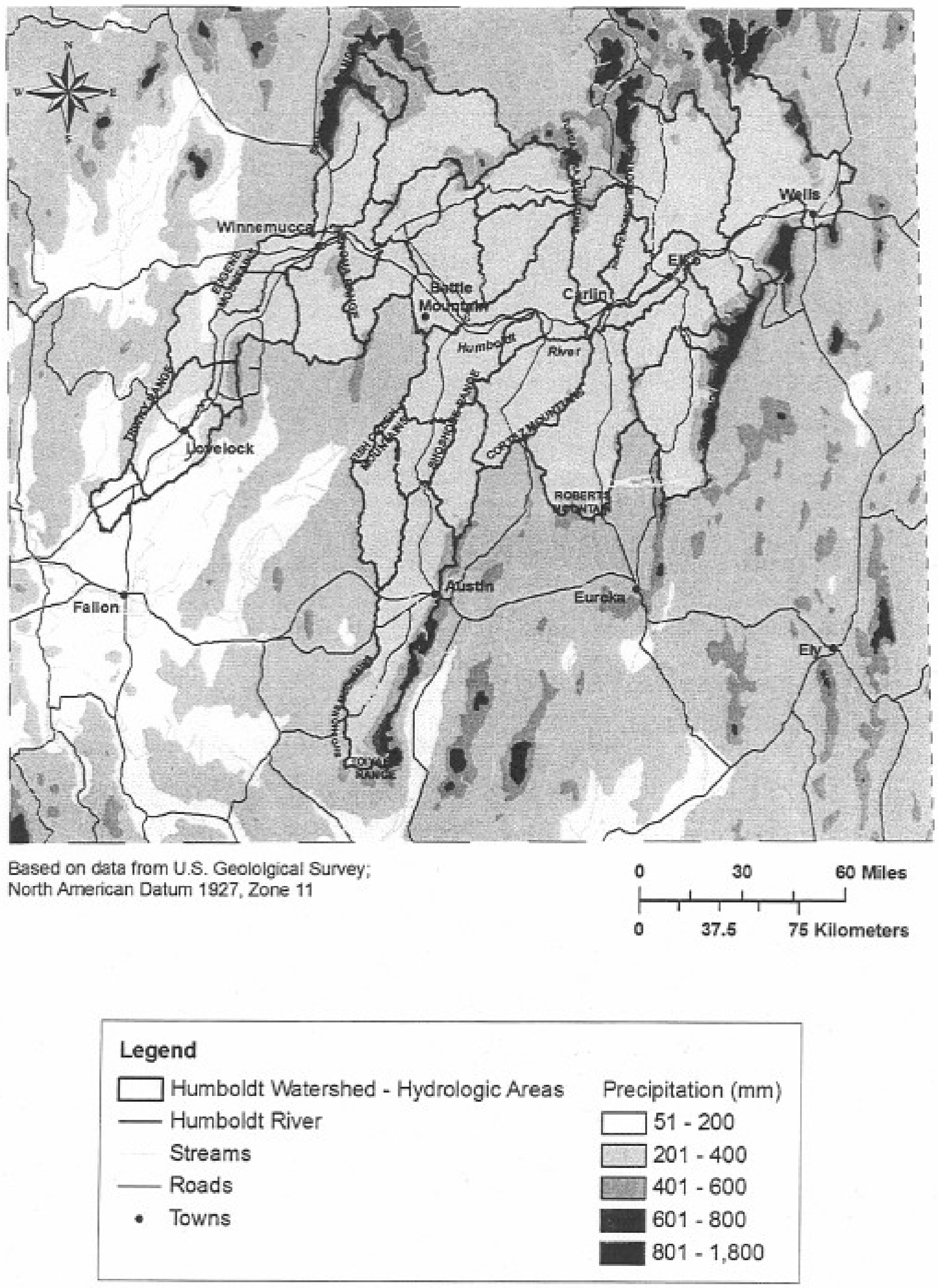

Figure 3 Precipitation pattern by PRISM

2.2.2 Additional Data Needs for NSE

Although precipitation is fairly well described for the Humboldt River Basin, additional gaging would be beneficial in assisting the state engineer in making water rights decisions. Precipitation data is particularly sparse in mountainous areas. Spatial coverage of precipitation can be improved through the use of the Next Generation Radar (NEXRAD) Doppler radar which collects precipitation data, and is operated by the National Weather Service. The processed data is displayed as a mosaic map that shows patterns of precipitations. The NEXRAD station located in Elko (http://www.wrh.noaa.gov/lkn/) could provide an additional method to acquire precipitation data.

2.2.3 Recommended Data Collection Activities

It is recommended that precipitation data be further investigated using the NEXRAD Doppler located in Elko. The NEXRAD data could be used to improve spatial estimates of precipitation across the basin. However, it is expected that large gaps will exist within the NEXRAD data. It is also recommended that additional precipitation gages be established in areas of the basin where current observations are not being made. For example, data is particularly sparse in the eastern and northern portions of the basin. Although precipitation is fairly well understood in the basin, additional data can be collected at a relatively low cost.

2.3. Groundwater Storage

2.3.1 Description of Available Reports and Data

Groundwater in the Humboldt River Basin is an important source of water supply. Because groundwater often supplements surface water resources, use of groundwater increases when stream flow is low. For the same reason, it decreases when runoff is high. It is therefore important to understand the past and the current appropriation.

The most comprehensive description of groundwater resources available in the Humboldt River Basin is from the series of reports produced by T.E. Eakin for the Nevada Department of Conservation and Natural Resources (DCNR) in the 1960s (Eakin, 1962; Eakin et al., 1965; Eakin & Lamke, 1966). Eakin (1962) estimated 3,000 acre-feet of groundwater was discharged by evapotranspiration, while the average annual groundwater discharge is approximately 5,000 acre-feet. According to Eakin & Lamke (1966), the volume of groundwater deposit is about three times the estimated average annual precipitation over the entire Humboldt River basin, and is approximately 28 million acre-ft. Within that estimation, about 9 million acre-ft are stored in the upper basin, while 13 million acre-ft is stored in the middle basin, and the remaining 6 acre-ft is stored in the lower basin. Digital copies of the Eakin reports have been included in the project database in PDF format.

Groundwater Level Data

Groundwater level data are collected primary by the USGS and NDWR. Factors such as changes in pumping rates and in climate lead to fluctuation of groundwater levels both seasonally and annually. The ground water database contains information including ground-water level and water-quality data, and it is managed by the USGS. There are 2067 monitoring wells in the Humboldt River Basin. However, only a small number of these wells have long-term records. Field water level data is readily retrievable from the USGS Ground-Water Data for Nevada site (http://nwis.waterdata.usgs.gov/nv/nwis/gwlevels). These contain water depth data manually measured from monitoring wells. Figure 4 depicts the locations of the monitoring wells in the Humboldt River Basin. The well locations have been included in the project database.

Another important source of information on groundwater resources is the well log database, maintained by the DCNR Division of Water Resources as further discussed below. We have obtained the most recent well log database and incorporated the data into the project database.

Modeling Studies

The USGS groundwater study, titled 'Cumulative Effects of Groundwater Withdrawal on Streamflow in the Middle Humboldt' will be finished in early March, 2007. Included in the study is a thorough analysis of recharge estimates and comparison to the results published by Maxey-Eakin. A preliminary estimate of recharge in the Middle Humboldt River Basin is 7% of total precipitation, or approximately 0.8 inches per year.

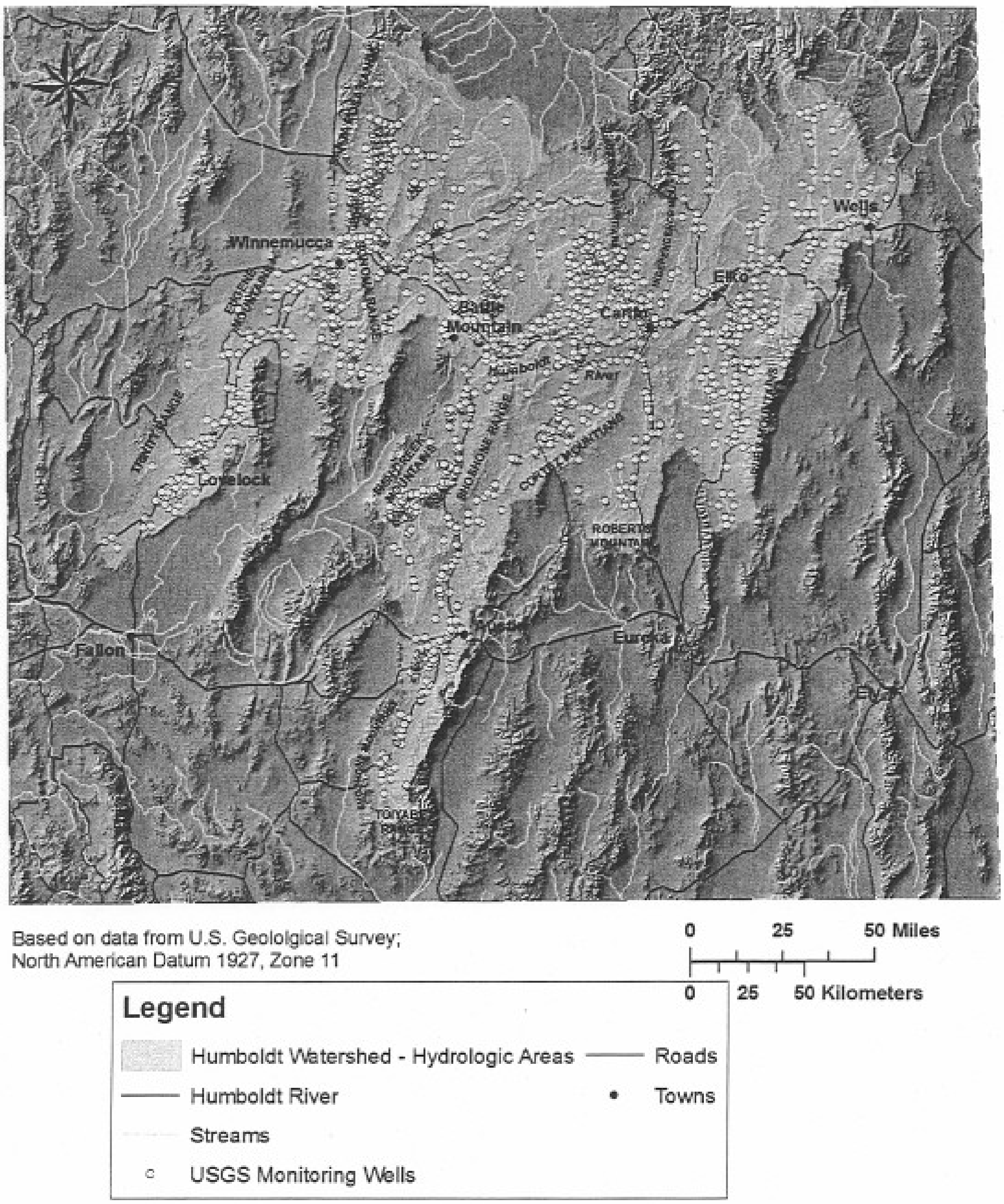

Figure 4 Monitoring wells in the Humboldt River Basin

2.3.2 Additional Data Needs for the Nevada State Engineer

Following previous Nevada State Engineer water rights hearings as an example, there are additional data needed in order to adequately prepare for a potential hearing in the Humboldt River Basin. It is critical to understand impacts of groundwater pumping rates on ecology, the local economy, and society. Currently there are only a couple of long-term monitoring wells in the Humboldt River Basin, which are operated by the U.S. Geological Survey. Thus, it is beneficial to establish more long-term monitoring wells to improve the quality and quantity of collected data.

An extensive MODFLOW model has been developed for a large portion of the Great Basin Regional Aquifer system. This model was used extensively in the recent Spring Valley water rights hearing, held by the Nevada State Engineer. This model covers a portion of the Humboldt River Basin and could be extended to encompass the entire basin. The results of the ongoing USGS modeling study will also provide much needed information regarding groundwater resources.

2.3.3 Recommended Data Collection Activities

We recommend that observations be increased at the basin's monitoring wells. Although, several thousand wells are in place, the frequency of data collected from those monitoring wells are not standardized or frequent enough to draw any substantial inferences. Adding pressure transducers and dataloggers to a portion of those wells would provide very valuable data at a relatively low cost. The wells should be selected to cover a broad spatial distribution with a higher concentration of wells near areas with high groundwater withdrawals (e.g. agricultural regions, towns, and mines). Another recommendation is to expand the Great Basin MODFLOW model to include the entire Humboldt River Basin. The model would be capable of assessing potential effects of groundwater pumping rates on various factors including the environment, ecology, agriculture, and the economy of the Humboldt River Basin.

2.4. Surface Water

2.4.1 Description of Available Reports and Data

Surface water in the Humboldt River Basin is dominated by a snowmelt driven spring melt. Thus, annual streamflow is closely correlated to snowpack accumulation at higher elevations. Maximum annual daily streamflow is typically observed in May and June. Streamflow is highly influenced by diversions and ET. For example, cumulative surface water diversions for irrigation above the Humboldt River at Comus (ID# 10327500) are approximately 200,000 acre-ft. Flows are also significantly influenced by discharge into the Humboldt River from mine de-watering. Daily mean flows vary dramatically within year and from year to year. The maximum peak flow of 15,000 cfs was observed in the Humboldt River occurred at the Carlin gage in 1910. At the other extreme, the river often goes completely dry at many locations during dry years. The daily mean flow of the Humboldt River for the period of record is 377 cfs at Carlin and 278 cfs at Imlay.

The USGS observes stream discharge at 17 stations in the Humboldt River Basin. The data is originally collected in 15-minute intervals at most sites, and historic data is available in daily increments. The daily records were obtained from the USGS NWIS Web Water Data website for all active stations. The data were summarized in terms of monthly and annual means and incorporated into the GIS database. The GIS database was then linked back to the daily records to allow for easy retrieval of raw data. The active streamflow gages are listed in Table 3 and their locations are shown in Figure 5.

The principle consumptive use for surface water in the Humboldt River Basin is irrigation of meadows and crops. Water is diverted and stored for irrigation at seven reservoirs in the Humboldt Basin. The Nevada State Water Plan summarized major reservoirs of the Humboldt River as following: lower Pitt-Taylor Reservoir (22,200 acre-ft); upper Pitt-Taylor Reservoir (24,200 acre-ft); Rye Patch Reservoir (194,300 acre-ft); South Fork Reservoir (41,000 acre-ft). Of these reservoirs, regular data for storage volume and discharge appear to be only available for Rye Patch Reservoir and Upper and Lower Pitt-Taylor Reservoirs. The Pershing County Water Conservation District maintains paper records of daily flow and storage for Rye Patch Reservoir and monthly records for the Pitt-Taylor Reservoirs.

Table 3. Summary of USGS stream gage station information

USGS ID	Site Name and URL
10313400	MARYS RIVER BELOW ORANGE BRIDGE http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10313400
10315600	MARYS RIVER BLW TWIN BUTTES NR DEETH, NV http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10315600
10316500	LAMOILLE C NR LAMOILLE, NV http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10316500
10317500	N F HUMBOLDT R AT DEVILS GATE NR HALLECK, NV http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10317500
10318500	HUMBOLDT R NR ELKO, NV http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10318500
10319900	S FK HUMBOLDT R ABV TENMILE CK NR ELKO, NV http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10319900
10320000	S F HUMBOLDT R AB DIXIE C NR ELKO, NV http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10320000
10321000	HUMBOLDT R NR CARLIN, NV http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10321000
10322000	MAGGIE CK AT CARLIN, NV http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10322000
10322500	HUMBOLDT R AT PALISADE, NV http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10322500
10324500	ROCK CK NR BATTLE MOUNTAIN, NV

http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10324500	
10324700	BOULDER CREEK NEAR DUNPHY, NV
http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10324700	
10325000	HUMBOLDT R AT BATTLE MOUNTAIN, NV
http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10325000	
10327500	HUMBOLDT R AT COMUS, NV
http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10327500	
10329500	MARTIN C NR PARADISE VALLEY, NV
http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10329500	
10333000	HUMBOLDT R NR IMLAY, NV
http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10333000	
10335000	HUMBOLDT R NR RYE PATCH, NV
http://waterdata.usgs.gov/nv/nwis/nwisman/?site_no=10335000	

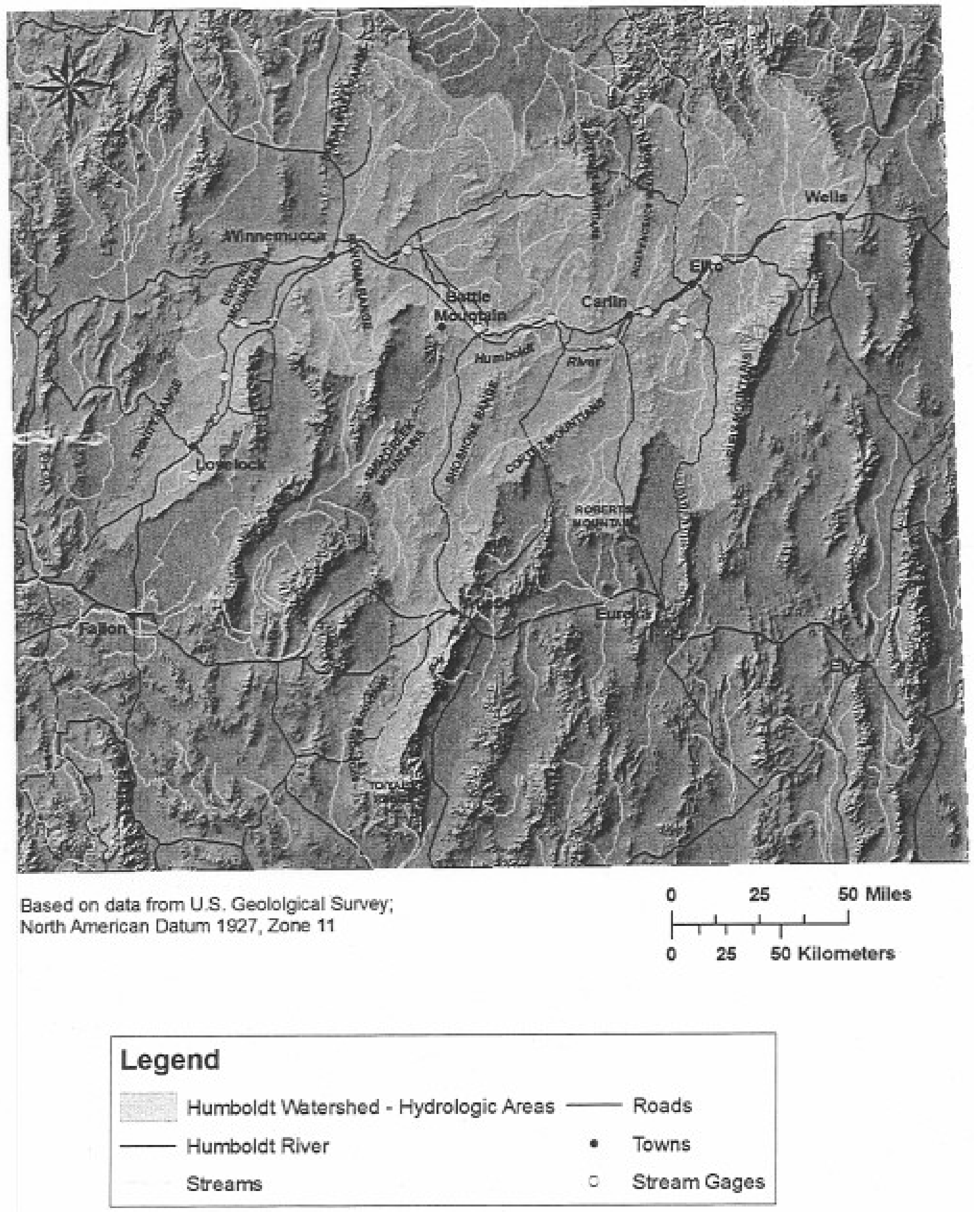

Figure 5 Stream gages in the Humboldt River Basin

2.4.2 Additional Data Needs for Nevada State Engineer

A thorough description of surface water resources is essential in order to support the decisions of the Nevada State Engineer. This data must describe both available water supply, allocation, and use. Surface water monitoring is complicated by regular diversions and return flows. Further, surface water/ground water interactions are not well understood in the irrigated regions near the Humboldt River and its tributaries.

2.4.3 Recommended Data Collection Activities

A high priority and relatively inexpensive collection activity is to obtain the paper copies of reservoir storage and discharge data and translate the data into a digital format. For the reservoirs lacking regular data, stage and discharge gages should be installed. Another priority is to improve measurements or estimates of surface diversions. This would allow for an improved description of the overall surface water budget.

2.5. Management of Ground Water and Surface Water Resources

2.5.1 Description of Available Reports and Data

The office of the Nevada State Engineer maintains several comprehensive databases and spreadsheets of data regarding withdrawals and consumptive uses of groundwater and surface water in the basin. They are currently in the process of updating their system from data stored in spreadsheets and Access databases to a central database server. However, they agreed to provide all their existing data, regardless of format. This data has been incorporated into the database developed for this project. This data includes details of water right permits for major water users in the basin.

The Nevada State Water Plan summarized approximate perennial yield and committed groundwater resources for the Humboldt River Basin in 1998 as follows – combined perennial yield (463,900 acre-ft); irrigation & stock (492,307 acre-ft); municipal & quasi-municipal (53,737 acre-ft); mining & milling (141,576 acre-ft); commercial & industrial (63,637 acre-ft); other (91,055 acre-ft); and total (842,312 acre-ft).

The State Engineer requires data describing groundwater pumping in the basin. Groundwater in the Humboldt River Basin is pumped for a variety of reasons including agriculture, mining, industrial, municipal, and power plants. In order to quantify the volume of water pumped from groundwater resources, Plume (2003) conducted a study on groundwater and its use in the Humboldt River Basin by collecting data from 14 hydrographic areas. The study included investigations of groundwater irrigation pumpage, and showed that estimated groundwater withdrawals for irrigation purposes were between 100,000 and 130,000 acre-feet during 1983-1999.

Scientific Investigations Report 2005-5199 published by the U.S. Geographical Survey summarized groundwater withdrawals in the Humboldt River Basin. A dramatic growth in population in the basin after 1980, due to gold mining opportunities, increased the groundwater withdrawal in the region. However, after 1998 the usage of groundwater in the basin was reduced due to a decline in mining operations. The study quantified the number of wells drilled annually for livestock watering, irrigation wells, municipal and industrial wells, and domestic wells on an annual basis. The report also describes water pumped for mine dewatering (Gold Quarry, Betze-Post, and Lone Tree Mines), which is often released to the Humboldt River or reused for irrigation. However, one major shortcoming in these studies is that the amount of water re-use in the basin has not been quantified.

Well Logs and Water Levels

The State Engineer's office currently maintains a database of well logs and water levels. The well logs database contains information such as: location, size (borehole diameter), lithology, and yield for every permitted well in the basin. This comprehensive database is up-to-date and drillers are required to submit this information for each new well.

The database also contains water level information. This data is updated less frequently, but gives information such as: status (active, inactive), owner, location, permit number, well log number, and water surface information. This database is in MS Access format and is currently incorporated into the master database created for this project. The station is managed by the USGS Elko field unit (http://waterdata.usgs.gov/nv/nwis). Well locations were added to the GIS database as shown in Figure 6.

Water Rights Database

The water rights database currently resides on a MS SQL server at the Division of Water Resources. Data can be accessed through their website (http://water.nv.gov/Water%20Rights/permitdb/permitdb_index.cfm?CFID=17035&CFTOKEN=26277579). This extensive database contains all the permitted and appropriated water rights for the State of Nevada. The data include information about current ownership, the point of diversion and place of use of the water right, diversion rates, and manner of use, well log information, protest and ruling information, as well as dates required for filing various proofs. Other data available includes scanned documents such as certificates, book records (permits), maps, and rulings.

Though the water rights database contains allocations for mining uses, including permitted pumping rates for mine dewatering, the measured rates of pumping and resulting discharge back to the Humboldt River (used for irrigation or returned to underground storage) are collected by the State Engineer field offices in Winnemucca and Elko. These data are currently stored in hard copies or in scanned document formats for eventual inclusion to a more comprehensive central database.

The water rights database and historic pumping rates database were obtained from the State Engineer and assimilated into our database where practical, including approximately 40 spreadsheets.

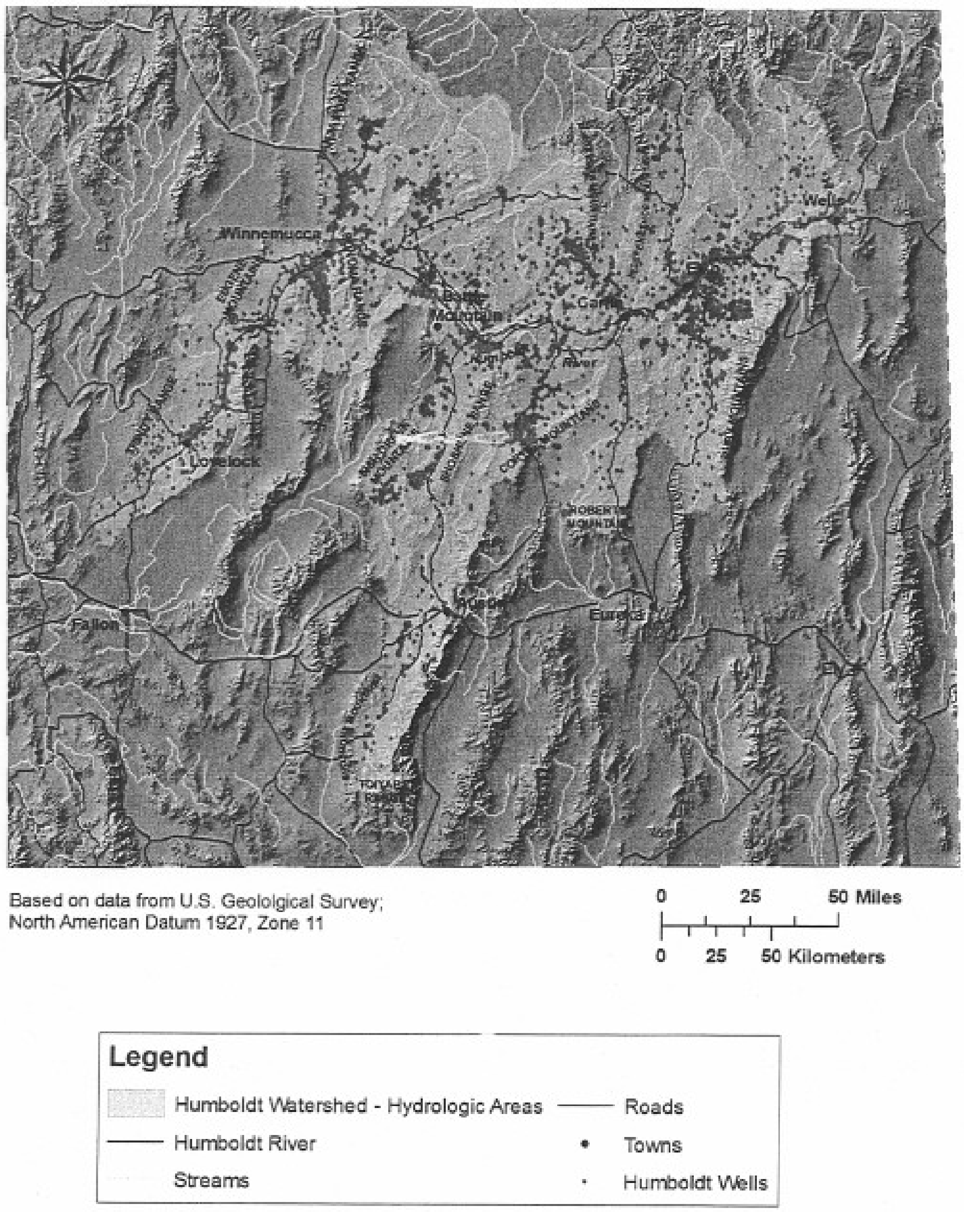

Figure 6 Wells in the Humboldt River Basin

Domestic Use

In Section 1 of the Nevada State Water Plan (Nevada Division of Water Resources), historic and current water use is included for all uses, including domestic. In 1995, domestic water use accounted for approximately 9% of the Humboldt basin's total ground water and surface water withdrawal. The USGS estimates a self-supplied (from domestic wells) water use rate of approximately 120 gallons per person per day. This rate is estimated as part of the National Water Use Information Program (State Engineer's Office, 1971) by assuming 90 percent of the county public-supplied domestic use rate. In the Humboldt basin, population changes appear to be tied to mining activities (NV State Water Plan, 1995). In other words, when mining activity increases, so does population. Population increases put pressure on agricultural water right holders to sell their water rights to other users. Even though the population of the Humboldt River Basin was stable from 1940 to 1960, water use slowly increased corresponding to an increase in drilled wells and irrigation opportunities between 1960 and 1980. After 1980, the population in the Humboldt River Basin increased dramatically, due to the development of large and low-grade gold deposits in the region. This led to an increase in employment opportunities in the area. The amount of groundwater withdrawals corresponds to both population growths from 1960 to 1980, and mining in the late 1980s.

It is unlikely the rate of water use will change, but the total amount of water use will likely change with population. Population trends are difficult to predict, but the Nevada State Water Plan predicts total domestic use for the state will increase from 9% to 16% by the year 2020. However, this estimate includes the extremely high rate of population growth in Clark County—a rate not experienced by the rest of the state.

Agricultural Use

By far the greatest use of water in the Humboldt basin is for irrigation and livestock, which accounted for 75% of the total consumption in 1995 (Nevada State Water Plan). The State Engineer's Office does not have detailed maps of irrigated lands in the basin, but approximate acreages and locations can be determined from the point of discharge (POD) and permitted quantities. Also, estimates can be obtained from the LANDSAT and MODIS images of the basin. The primary crop in the basin is alfalfa, which takes approximately 3.5 to 4 acre-feet of water per acre per year. Chen (1978) estimated that water use for irrigated crops is about 35 inches per year above Palisade and approximately 39 inches per year below Palisade.

Changes in the irrigated acreage will likely be related to population changes. Statewide, agricultural use of water is expected to decline from 77% of the total water withdrawal to 66%. The primary reference for agricultural use is the Water Rights Database, which provides a historical record of ground water and surface water withdrawals for agricultural use. Past studies reported that the estimated groundwater withdrawals for irrigation ranges from 100,000 to 130,000 acre-ft per year during the period between 1983 and 1999 (for review, please see Cohen, 1963, 1964; Eakin, 1962; Eakin & Lamke, 1966; Eakin, Moore, & Everett, 1965; Eakin, Price, Don, & Harrill, 1976; Everett & Rush, 1966).

Mining Use

Statewide, mining accounts for about 7% of the ground water and surface water withdrawals in the state. Withdrawals specifically for the Humboldt River Basin will be higher than the state average and will be determined from historic withdrawal rates. According to the Nevada State Water Plan (1995), withdrawals and consumptive use due to mining has quadrupled since the mid-1980s.

In 1990, the water use increased greatly to 28,000 acre-ft per year from approximately 2,000 acre-ft per year in 1988. It increased rapidly to 120,000 acre-ft per year in 1992 due to dewatering of mines (Prudic, Niswonger, & Plume, 2005). Dewatering pumps at large gold mines are capable of withdrawing more than 1,000 gallon of water per a minute. The total amount of the discharge from dewatering ranges from 10,000 gallon per minute to 50,000 gallon per minute (Barrick Goldstrike Mines Inc., 2000). According to Horton (2001), the amount of about 70% of the mean flow of the Humboldt River was permitted to be discharged in the late 1990's (Prudic, Niswonger, & Plume, 2005). Some of the groundwater pumped for mine dewatering was substituted for irrigation. According to Plume, as much as 16% of mine de-watering water is re-used for irrigation (Plume, 2003). However, this figure is not well documented.

2.5.2 Additional Data Needs for Nevada State Engineer

Based on previous water rights hearings held by the State Engineer, additional data should be collected in order to better describe water use and management in the Humboldt River Basin. Following discussions with employees at the State Engineer's Office, a gap of knowledge exists between permitted water rights and actual water consumption. Most water right holders are not required to report detailed usage histories. In many cases, water use is not even measured. In other cases, such as mining, detailed records are kept and reported to the State Engineer, but adequate resources are not available to review and process this data.

2.5.3 Recommended Data Collection Activities

Future studies must focus on narrowing the knowledge gap between allocated and utilized water rights. Such studies should focus on water budget components with the highest level of consumption and uncertainty. We recommend that the great efforts be placed on quantifying actual consumptive use by irrigated agriculture and the amount of mine de-watering water, which is reused. Because the water consumed by irrigation is almost entirely lost to ET, this recommended activity is directly related to the ET monitoring recommendations discussed above. A combination of direct field measurements, climate data analyses, and remote sensing techniques should be used. Regarding mine de-watering, most of the required data is already being collected and reported by the mining industry. The appropriate resources should be provided to the State Engineer's Office to analyze the de-watering data collected and reported by the mining industry.

Refining consumptive water use by other sectors (domestic, industrial, municipal, etc.) should also be completed as resources allow.

3. Water Quality Data

3.1. Summary

The Nevada Division of Environmental Protection's primary mission is to protect the waters of the state. To that end, they rely on in-stream water quality data to assess the health of each waterbody. The Bureau of Water Quality Protection (BWQP) maintains a monitoring network of 17 sites on the main stem and tributaries of the Humboldt River and collect data for 42 parameters. Many of these sites have over 30 years of sample data. The typical schedule is to sample every two months for conventional pollutants and every six months for metals.

There are three primary sources of water quality data available: BWQP's regular monitoring program, water quality sampling by the mines, and USGS Open File Reports and Water Resources Investigations reports.

The current monitoring network is the minimum required to meet BWQP's goals. Given the value in large datasets with long periods of record, it is recommended that this program continue. However, the Impaired Waters List submitted to the EPA in 2004 (USEPA, 2005) identifies many reaches of streams that warrant further investigation. These reaches were included if there was insufficient evidence to place the waterbody on the 303(d) list—usually due to limited data—but enough evidence to indicate potential future problems. It is recommended that all the reaches listed in Appendix C (List of Waterbodies Warranting Further Investigation) of the 2004 303(d) list be added to the monitoring plan.

Finally, though this recommendation does not specifically address data gaps, the lack of a coordinated, central database as a repository for all water quality data is a critical issue. Much of the data collected resides on spreadsheets, on CDs in a desk drawer, or even on paper. These data are available, but the difficulty in retrieving it all may prove detrimental to any further studies in the basin. It is therefore recommended that development and maintenance of a centralized database be a priority.

3.2. Introduction

The Humboldt River Basin is the largest watershed in Nevada, but is not as extensively studied as other Nevada watersheds. The basin has a history and present that include mining, industry, agriculture and grazing. These land uses create disturbances within the watershed. For the Nevada Department of Environmental Protection to adhere to its anti-degradation Requirement to Maintain Existing Water Quality (RMHQ) standards and to establish Total Maximum Daily Load (TMDL) standards for waters in the basin, a suitable monitoring program needs to be established. This document provides background, bibliographic information and recommendations to increase the knowledge of water quality activities in the Humboldt Basin and to fully exploit the data that is available to maintain or improve the water quality in the basin.

First, the ultimate water quality objectives must be defined for identified water bodies in the basin, potential sources of pollution and degradation need to be identified, then water quality standards need to be identified and ultimately a regular monitoring program for key stream reaches must be established. This process is proceeding under guidelines set by Nevada Administrative Code (445A.119 – 445A.225) and the federal Clean Water Act (CWA) of 1977. Specifically, section 303(d) of the Clean Water Act requires each state to define reaches of streams whose designated beneficial use is impaired by pollutants. Nevada's most recent 303(d) list of impaired waters was approved in 2005 by the US Environmental Protection Agency. The list includes 28 stream reaches within the Humboldt River Basin. On each of these reaches the CWA requires that Total Maximum Daily Load (TMDL) standards be set for various pollutants of concern.

This section of the report will outline the existing water quality standards in the basin, the existing surface water quality monitoring programs, gaps in data needed to define TMDL standards and recommendations for supplementary water quality monitoring programs within the Humboldt River Basin.

3.2.1 Total Maximum Daily Load

A Total Maximum Daily Load (TMDL) is a numeric standard for a given pollutant that describes the allowable level of that pollutant in a given waterbody. For example on the Humboldt River the reach from Osino to Palisade has a TMDL standard for total phosphorous of 426 pounds/day or an annual average of <0.1 mg/l. This standard is intended to take into account pollution entering the waterbody from all sources including discharges from sewage treatment, industry, agriculture, urban runoff and natural sources.

In addition to their usefulness in quantifying water quality standards, TMDLs provide a way divide the input of the pollutant amongst the pollution sources using wasteload allocations for point sources of pollution such as agricultural drains and load allocations for non-point sources such as runoff. TMDLs are an aid to bringing waterbodies into compliance with their assigned water quality standards.

All waters listed in the states EPA approved 303(d) list must have a plan for establishing TMDL for the pollutants of concern. After the TMDL is established the state must continue to monitor the stream reach for the pollutant to establish that the TMDL is not exceeded. If the stream comes back into compliance with water quality standards after continued monitoring it can be removed form the 303(d) list.

3.2.2 Overview of Beneficial Uses

Beneficial uses, also known as designated uses, are narrative statements describing the intended human or environmental uses of a waterbody. In Nevada, reaches of streams and rivers have defined beneficial uses based on their location, historical use of the water body and industrial activity in the area. The most common beneficial use designations in the Humboldt River watershed are: municipal water supply with treatment, domestic supply with disinfectant or filtration treatment, aquatic life, propagation of wildlife, irrigation, watering of livestock, recreation including contact with the water and recreation not involving contact with the water. These beneficial use descriptions are an aid to water quality planning and TMDL development.

The beneficial use statements are found in the Nevada Administrative Code Chapter 445A.

445A.122:
(a) Watering of livestock. The water must be suitable for the watering of livestock without treatment.
(b) Irrigation. The water must be suitable for irrigation without treatment.
(c) Aquatic life. The water must be suitable as a habitat for fish and other aquatic life existing in a body of water. This does not preclude the reestablishment of other fish or aquatic life.
(d) Recreation involving contact with the water. There must be no evidence of man-made pollution, floating debris, sludge accumulation or similar pollutants.
(e) Recreation not involving contact with the water. The water must be free from:
Visible floating, suspended or settled solids arising from man's activities

- Sludge banks
- Slime infestation
- Heavy growth of attached plants, blooms or high concentrations of plankton, discoloration or excessive acidity or alkalinity that leads to corrosion of boats and docks;
- Surfactants that foam when the water is agitated or aerated; and
- Excessive water temperatures.

(f) Municipal or domestic supply. The water must be capable of being treated by conventional methods of water treatment in order to comply with Nevada's drinking water standards
(g) Industrial supply. The water must be treatable to provide a quality of water which is suitable for the intended use.
(h) Propagation of wildlife. The water must be suitable for the propagation of wildlife and waterfowl without treatment.
(i) Waters of extraordinary ecological or aesthetic value. The unique ecological or aesthetic value of the water must be maintained.
(j) Enhancement of water quality. The water must support natural enhancement or improvement of water quality in any water which is downstream.

Nevada uses the class system to determine if the designated beneficial uses of a water body are violated. These beneficial uses of each class are defined in the Nevada Administrative Code:

445A. 124: The beneficial uses of class A waters are municipal or domestic supply, or both, with treatment by disinfection only, aquatic life, propagation of wildlife, irrigation, watering of livestock, recreation including contact with the water and recreation not involving contact with the water.

445A.125: The beneficial uses of class B water are municipal or domestic supply, or both, with treatment by disinfection and filtration only, irrigation, watering of livestock, aquatic life and propagation of wildlife, recreation involving contact with the water, recreation not involving contact with the water, and industrial supply.

445A.126: The beneficial uses of class C water are municipal or domestic supply, or both, following complete treatment, irrigation, watering of livestock, aquatic life, propagation of wildlife, recreation involving contact with the water, recreation not involving contact with the water, and industrial supply.

445A.127: The beneficial uses of class D waters are recreation not involving contact with the water, aquatic life, propagation of wildlife, irrigation, watering of livestock, and industrial supply except for food processing purposes.

In addition to having defined beneficial uses, each class is defined by its water quality standards and location. Class A waters cannot have floating solid waste, sewage, industrial waste, and have numeric standards for temperature, pH, fecal coliform, total phosphorus and Total Dissolved Solids (TDS). Class B and Class C waters have narrative standards for floating solids, sludge deposits, sewage, industrial wastes, odor producing substances, toxic material, oil and numeric standards for pH, dissolved oxygen, temperature, fecal coliform, total phosphorus, and TDS. Class D waters have narrative standards for floating solids, sewage, toxic materials and numeric standards for pH and dissolved oxygen.

Class A waters are located away from human habitation in more undisturbed areas and class D waters are in areas of urban development or other heavy human use. Waters of Class B or C waters lie in areas with light to moderate industrial disturbance or human habitation.

The NDEP has maintained monitoring stations on the Humboldt River for more than ten years and has been able to use this data to determine if the beneficial uses of the waters are violated and to create a CWA 303(d) list.

3.2.3 Nevada's 303(d) List

The Nevada Division of Environmental Protection developed its 303(d) list using primarily numeric data related to chemical pollutants in Nevada streams. Some states use other available data such as sediment, fish tissue and narrative information, but the Nevada Department of Environmental Protection did not find these data readily available. The most recent list is based largely on the past 303(d) list from 2002, the 305(b) National Water Quality Inventory list from 2000 and the ongoing monitoring conducted by the NDEP. In addition streams were added to the 2004 303(d) list if a fishing, drinking or swimming advisory went into effect for the waterbody during the listing period.

The Nevada Department of Environmental Protection maintains a suite of monitoring stations in the Humboldt River Basin and additional monitoring programs are maintained by some mining operations and the US Geological Survey. These monitoring programs form the basis for many of the current listing of particular stream reaches on the 303(d) list. If more that 10 percent of the samples in the sampling period exceed the standard for any pollutant monitored then the reach can be placed on the 303(d) or 305 list.

For the 2004 303(d) list the monitoring period was from 1997 through 2003. If the reach is on a previous 303(d) list it can only be removed if: 10 or more samples have been taken and no more than 10 percent have exceed the standard; it is found that it was originally listed erroneously; it will be continued to be monitored to meet Nevada's Requirement to Maintain High Quality; or it is found to actually be part of another reach of stream by the "tributary" rule. For each reach with an associated monitoring station there are a suite of parameters used to determine if the designated uses of the reach are violated.

More detail on the 303(d) list, particularly as it pertains to the current Humboldt River monitoring network, is provided below.

3.3. Summary of Historic Monitoring in the Humboldt River Basin

3.3.1 Nevada Division of Environmental Protection

NDEP has been monitoring surface water sites in the Humboldt River Basin since 1968. The main focus of the monitoring programs, based on the number, frequency, and location of samples, is the main stem of the Humboldt. Figure 7 shows the location of every site recorded in NDEP's water quality database. Many of the sites in the database are not considered active sites and may contain only a few samples. Figure 8 shows an example of the frequency of sampling for every site in NDEP's database for each parameter, in this case, alkalinity. Data exist for over 100 parameters in the database.

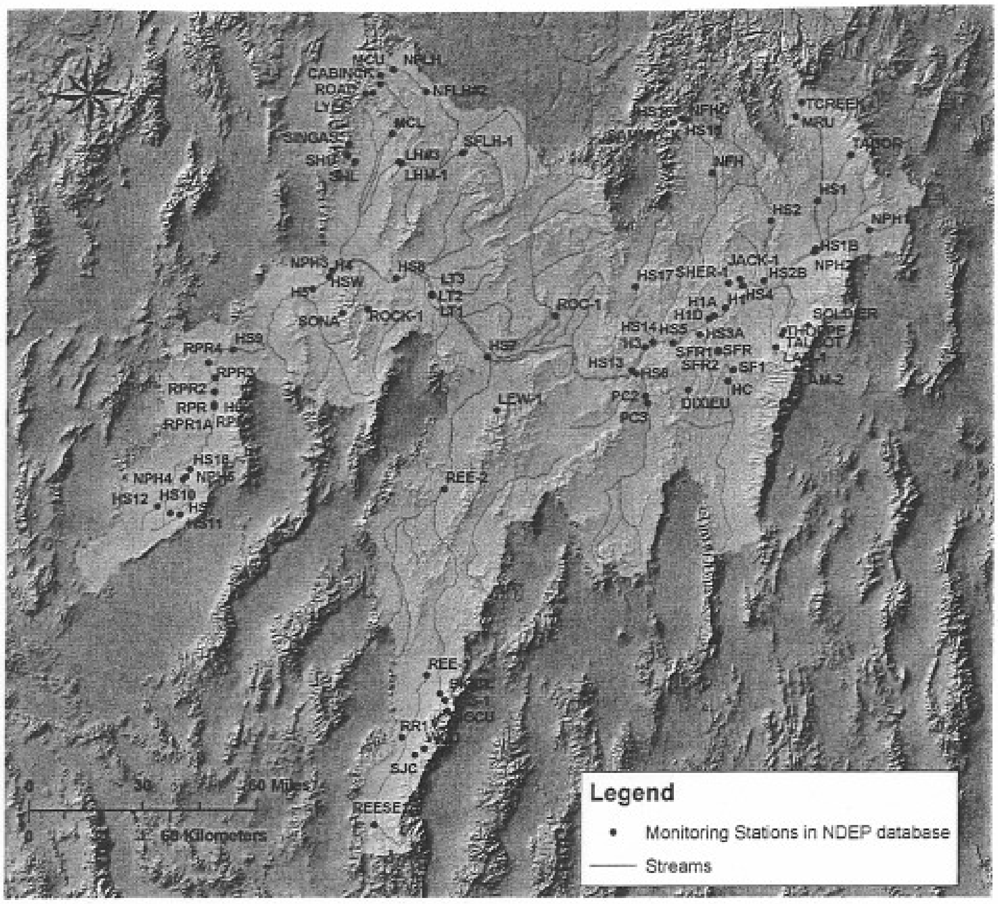

Figure 7 Monitoring stations in NDEP database

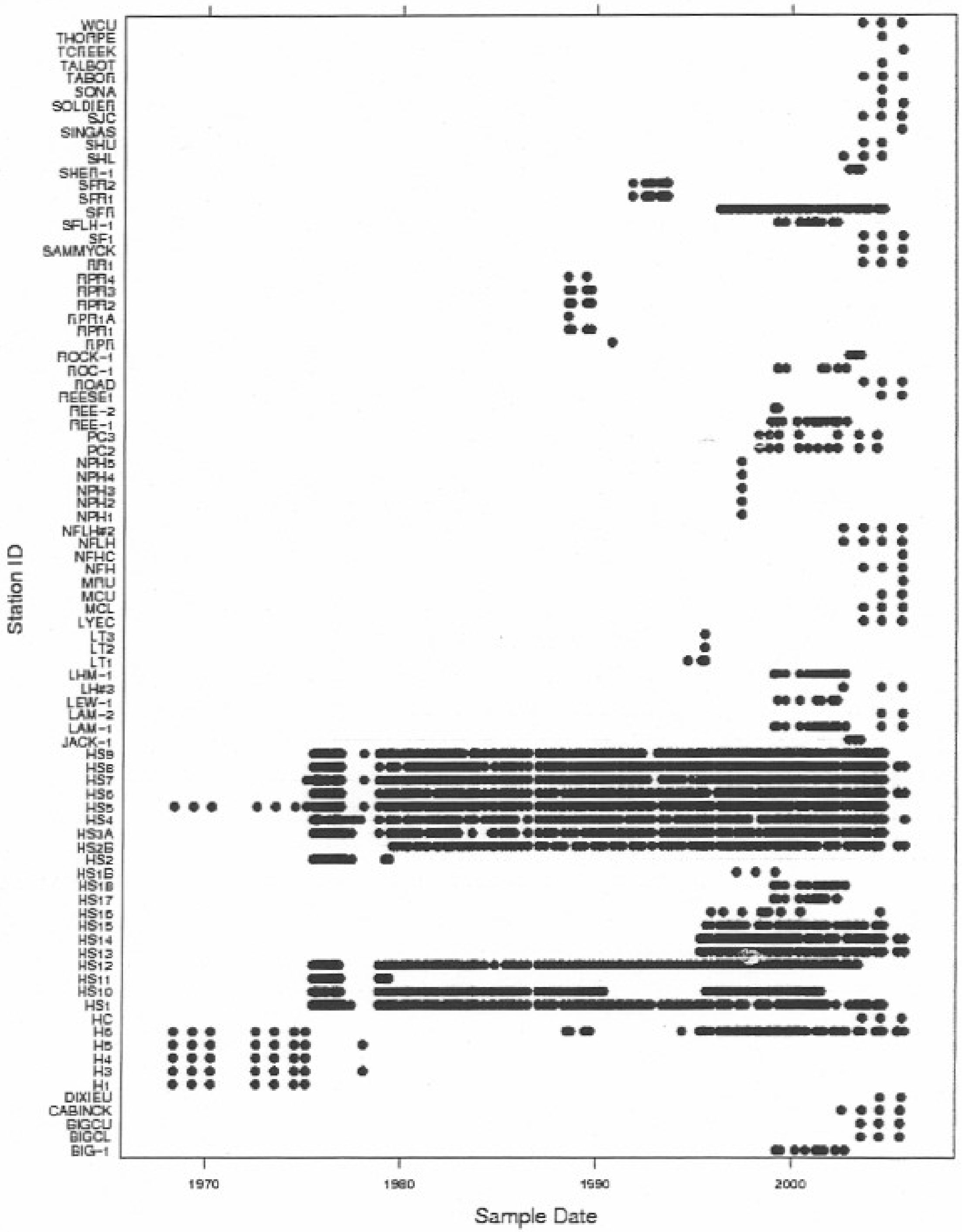

Figure 8 Sampling frequency for all sites in NDEP database

NDEP is the principal repository for all water quality monitoring occurring in the state. The data are submitted to NDEP in various formats, primarily spreadsheets and paper copies, and input to a MS Access database. For this study, a copy of the entire database was obtained directly from NDEP. A digital copy of the database is included in this report. In anticipation of an ever-increasing number of records, NDEP is in the process of converting their entire database to a MS SQL Database server. As of the date of this report the conversion is incomplete; therefore, the MS Access database is the most up-to-date data source for NDEP.

3.3.2 Humboldt Basin Mines

In the portion of the Humboldt Basin that lies in the Elko District of the Bureau of Land Management (BLM) there are at least two surface monitoring programs of note, run by mining corporations in relation to their mining operation permits mandated by state and federal regulations. Barrick Goldstrike Mines Inc. is the owner of one of the larger mining projects in the Humboldt Basin. The mine is required to submit an update of the monitoring plan for Boulder Valley twice a year to the Nevada Division of Water Resources State Engineer (NDWR). There are 20 stations on six creeks in the basin which are sampled quarterly. The Boulder Valley Monitoring Plan report is submitted on CD to NDWR and to the BLM Elko field office. There are four stations on Antelope Creek, two stations on Bell Creek, four on Boulder Creek, two on Brush Creek, four on Rock Creek, and four on Rodeo Creek. At each location the water sample is analyzed for the following chemical constituents: alkalinity, aluminum, antimony, arsenic, barium, beryllium, total bicarbonate, boron, cadmium, calcium, carbonate, chloride, chromium, copper, electrical conductivity, fluoride, iron, lead, magnesium, manganese, mercury, nickel, nitrite, nitrate, pH, potassium, selenium, silver, sodium, sulfate, temperature, thallium, total dissolved solids, and zinc. The Boulder Valley Monitoring Plan has been in effect since April 1991.

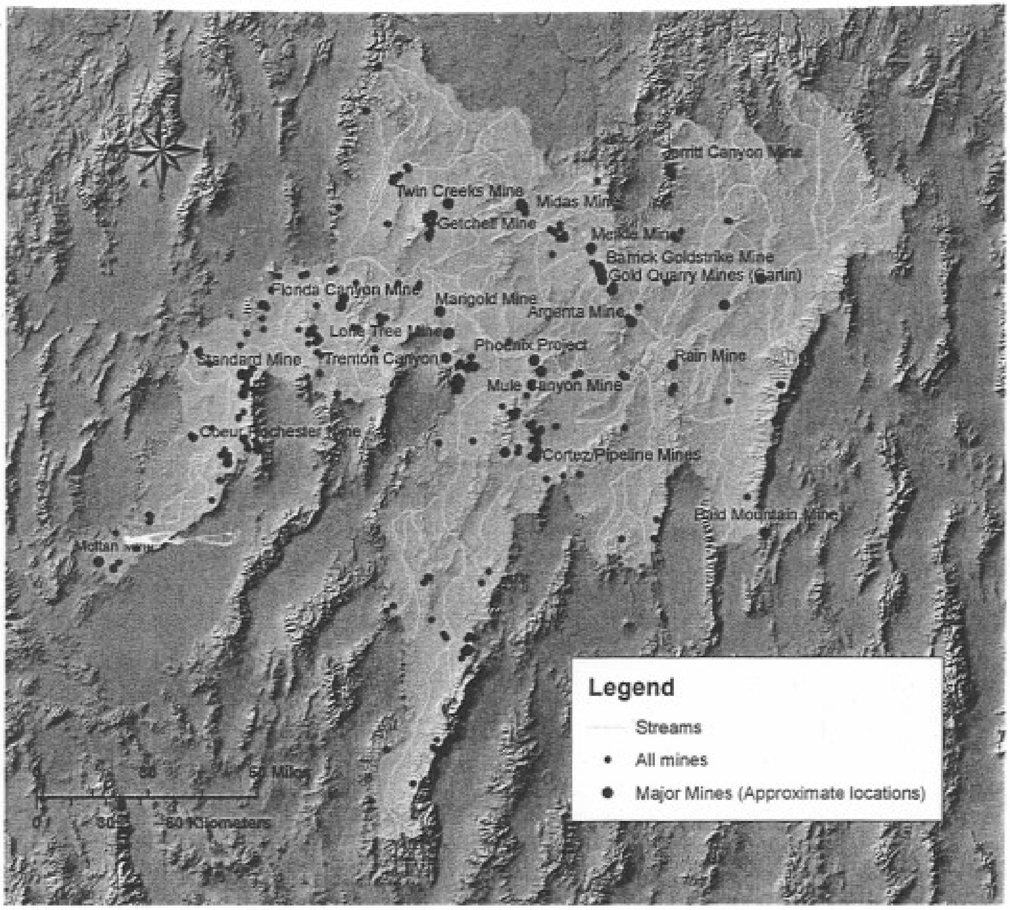

Figure 9 Major Mines

Newmont Mining Corporation has a similar report for the adjacent Maggie Creek Basin. The report is submitted on CD to the BLM Elko field office. In addition Newmont representatives meet with the regulatory agencies at the offices NDWR to present the report. The CD contains the results of ground and surface-water monitoring related to dewatering operations in the Gold Quarry and Leeville mines. Samples are collected from eight sites: one on Susie Creek, one on Simon Creek, two sites on Maggie Creek and three sites on the main stem of the Humboldt River. Data has been collected at these sites since June 1996. Water is analyzed at all of the sites for alkalinity, bicarbonate, calcium, magnesium, potassium, sodium, sulfate, total suspended solids, total dissolved solids, arsenic, chromium, mercury, pH, temperature, and dissolved oxygen. From 1996-98 the water was also analyzed for antimony, barium, copper, iron, lead, manganese and selenium, uranium and fluoride. This data is found on each of the CD reports as historical reference.

In the Battle Mountain district of the BLM the large mining operations are the Barrick Crescent Valley Pipeline, the Newmont Phoenix Mine, the Santa Fe Pacific Gold Corporation Mule Canyon Mine and the Newmont Echo Bay-McCoy Cove Mine that is now in reclamation. Each of these mines has a quarterly monitoring program and submits reports semi-annually. Each monitoring program differs based on the specific permit requirements of the mine operation. The Phoenix mine does not have a surface water monitoring program. Each of the reports is available at the Battle Mountain BLM field office. Some smaller mines in the district send the results of their on- and off-site monitoring programs to the BLM field offices. The information can be obtained on request. If the operations are small or completely contained on private land, the BLM does not require monitoring. There may still be on-site monitoring reports that are submitted to NDWR.

The Winnemucca BLM field office has jurisdiction over several large mines: the Santa Fe Gold Twin Creeks Mine, Lone Tree Mine, Newmont Trenton Canyon Project, Florida Canyon Mine and Glamis Marigold Mine. In compliance with their permits and federal environmental regulations these mine operations submit periodic monitoring reports to NDWR and the BLM office.

The BLM field offices are also the conservators of Environmental Impact Statements as are required by federal regulations for proposed mines and mine expansions. The offices also have reports, data, comments and models that are used to create each EIS. These documents include ground water models, pit lake chemical models, risk assessment reports and subsidence estimates. Each EIS addresses potential issues and solutions for the following environmental areas: Water resources and geochemistry; air quality; vegetation resources; wildlife and fisheries resources; special status species; range resources; land use and access; aesthetics (visual and noise resources); and cultural resources, ethnography, and paleontology.

If a mine has not substantially changed its operations since the EIS requirement was enacted for mines (the EIS process grew out of the National Environmental Protection Act passed in 1969) or the mine is in reclamation there will not be an EIS available, though there may still be monitoring activities performed on-site by the mining corporation. Also, though the BLM is the primary location for all water quality data collected by the mines, the data are also submitted to NDEP and the Nevada State Engineer. Currently, most data still reside on CD and have not been included in NDEP's database. All documentation required for NEPA compliance resides in the BLM field offices. The table below summarizes the status and location of EISs relevant to mines in the Humboldt River basin.

Name	Operator	NEPA document, year
Winnemucca District Field Office		
Twin Creeks Mine	Newmont Mining Corp.	EIS, 1996*
Getchell, Turquoise Ridge	Barrick Gold Corporation	Various EAs
Pinson Mine	Barrick Gold Corporation	EA for closure
Trenton Canyon Mine	Newmont Mining Corp.	EIS 1998*
Lone Tree Mine	Newmont Mining Corp.	EIS 1995*
Marigold Mine	Glamis Gold, Inc.	EIS 2000*, 2003
Florida Canyon	Florida Canyon Mining, Inc./Standard Mine	EIS 1997*
Coeur Rochester Mine	Coeur D'Alene Mines, Corp.	Closure in progress
Battle Mountain Field Office		
Argenta Mine and Mill	Baker Hughes Fluids	N/A
Cortez Gold Mines/Pipeline/South Pipeline Pit Expansion	Cortez Joint Venture	EIS, 1996*, 2000, 2004
Phoenix Project	Newmont Mining Corp.	EIS, 2001*
Mule Canyon Mine	Newmont Mining Corp.	EIS, 1996*
McCoy Cove Project	Currently Newmont Mining Corp.	EA, 1986
Black Rock Canyon Placer Project	Cortez Joint Venture	EA, 2006
Elko Field Office		
Goldstrike Mine	Barrick Gold Corp.	EIS 1991, SEIA 2003 (supplemental for dewatering)
Gold Quarry (Carlin Mines)	Newmont Mining Corp.	EIS, 1993*, Amended 2002
Leeville Mine	Newmont Mining Corp.	EIS
Emigrant (prospective)	Newmont Mining Corp.	EIS
Jerritt Canyon Mine	Queenstake Resources	N/A private
Kinsley Mine	Alta Gold	EA
Meikle Mine	Barrick Gold Corp.	EA
Rodeo Mine	Newmont Mining Corp.	EA
Bootstrap Mine	Newmont Mining Corp.	EA, EIS 1996*
Tara Mine	Newmont Mining Corp.	EA

Name	Operator	NEPA document, year
Rain Mine	Newmont Mining Corp.	EA

* Copies of the draft and final EIS are available at the BLM state office in Reno. All supplementary reports and ongoing monitoring data must be retrieved at the district office.

Finally, the following personal contacts were instrumental in the data search and may be useful in future data collection efforts:

Thomas T. Olsen, Ph.D, Geological Engineer, US Department of the Interior, Bureau of Land Management, Nevada State Office.

Craig Drake, Hydrologist, US Department of the Interior, Bureau of Land Management, Winnemucca Field Office.

John Sherve, Hydrologist US Department of the Interior, Bureau of Land Management Battle Mountain Field Office.

Kirk Laird, Geologist, US Department of the Interior, Bureau of Land Management Elko Field Office.

Gary Johnson, Information Systems Specialist, Nevada Bureau of Mines and Geology.

3.3.3 Academic Theses

The University of Nevada holds at least twelve theses related to water quality and geology in the Humboldt River basin. The topics of these theses are, in general, one of: groundwater modeling studies (Bennet, 1999; Larsen, 1967; Pasternak, 1999); groundwater reconnaissance (Larsen, 1967); geochemistry related to mining activity (Bennet, 1999; Paul, 2003); or statistical analysis of existing data (Chen, 1978; Elges, 1934; Pautsch, 1978; Ryan, 1998).

3.3.4 Other Data Sources

Other data sources include monitoring required as part of NPDES discharge permits and Nevada Groundwater permits. These permits are administered by the Nevada Bureau of Water Pollution Control. Unfortunately, monitoring data is submitted in paper format and is not readily-accessible. An interview with the Bureau revealed that an effort is underway to enter the data from these paper copies into a centralized database; that effort is currently in the primary stages and no database has yet been developed. However, as stated above, many of the major mines in the basin submit the results of their entire monitoring network to the BLM field offices and likely overlap with the requirements of their discharge permits.

The USGS performed a study from 1995 to 1999 resulting in a report in 2000 (USGS, 2000) on the hydrogeochemical processes related to mining in the Humboldt watershed. In this study, geochemistry data were collected from mined rocks, mill tailings, altered rocks, springs and streams. The USGS was primarily concerned with the potential contributions of acid or metals to surface waters. As is discussed below, data collected in this study were used to identify streams to be included in the List of Waterbodies Warranting Further Investigation of the 2004 303(d) list. Data are available in CSV format online at http://pubs.usgs.gov/of/2000/ofr-00-0459/csv/.

The now-inactive National Irrigation Water Quality Program is an intra-agency program created to evaluate the impacts from all chemicals transported by irrigation drainwater to areas used by fish and wildlife. Though the program is suspended due to a reduction in funding, water quality data were collected in the Stillwater Wildlife Refuge from 1986 to 1989, and in the Humboldt River basin near Winnemucca between 1986 and 1990. Data are available online: http://www.usbr.gov/niwqp/data/wat/watdata.html.

The USGS also produced a study in 2004 (Paul, 2004) to collect data in and near the Humboldt Sink upstream to Imlay.. Previous studies (Seiler, et. al, 1993; Seiler and Tuttle, 1997) found high levels of dissolved solids, arsenic, boron, mercury, molybdenum, selenium, and uranium. Data were collected in streams, drains, and bottom sediments. The report can be found online: http://pubs.usgs.gov/of/2003/ofr03335/ofr03335.app.pdf.

3.4. NDEP's Current Monitoring Program

NDEP has a long history of monitoring in the Humboldt River Basin, beginning in the mid 1960s. As indicated in the database, there are 90 sites with water quality data (not including those sites monitored by the mines). Of those, approximately 17 sites are part of NDEP's regular monitoring program. In general, sampling is performed six times per year. Samples to be analyzed for conventional pollutants are collected every visit, while samples for metals are collected twice yearly, typically in February and July. The table below summarizes the parameters NDEP samples for in the Humboldt basin (reproduced from 303(d) list).

<u>Conventional Pollutants</u>	COD
Total Dissolved Solids	BOD
Total Suspended Solids	Sulfate
Electrical Conductivity	Calcium
Turbidity	Magnesium
Color	Sodium
pH-field	Hardness as CaCO3
pH-lab	Sodium Adsorption Ratio
Temperature	Fecal Coliform
Alkalinity as CaCO3	Fecal Streptococcus
Bicarbonate as CaCO3	E. Coliform
Carbonate as CO3	<u>Metals (total and filtered)</u>
Carbonate as CaCO3	Cadmium
Kjeldahl Nitrogen	Zinc
Nitrate as NO3	Chromium
Nitrate as N	Arsenic
Nitrite as N	Copper
Ammonia as N	Boron
Total Nitrogen	Iron
Ortho-phosphorus as P	Selenium
Total Phosphorus as P	Mercury
Chloride	Lead

NDEP focuses its sampling efforts primarily on 17 stations. They are listed below in Table 3 and Figure 10.

Table 3 NDEP's regular monitoring network

Name	ID
Mary's River	HS1
N.Fk. Humboldt River at I-80	HS2B
N.Fk. Humboldt River at N.F. Ranch	HS15
N.Fk. Humboldt River at Taco Tunnel	HS16
Humboldt River at Osino Cutoff	HS4
S.Fk. Humboldt River below Dixie Creek	HS3A
Humboldt River near Carlin Bridge	HS5
Humboldt River near Palisade	HS6
Humboldt River at Battle Mountain	HS7
Humboldt River at Comus	HS8
Humboldt River near Imlay	HS9
Toulon Drain	HS10
Humboldt River near Humboldt Sink	HS12
Pine Creek	HS13

Maggie Creek	HS14
South Fork Reservoir	SFR
Below Rye Patch Reservoir	H6

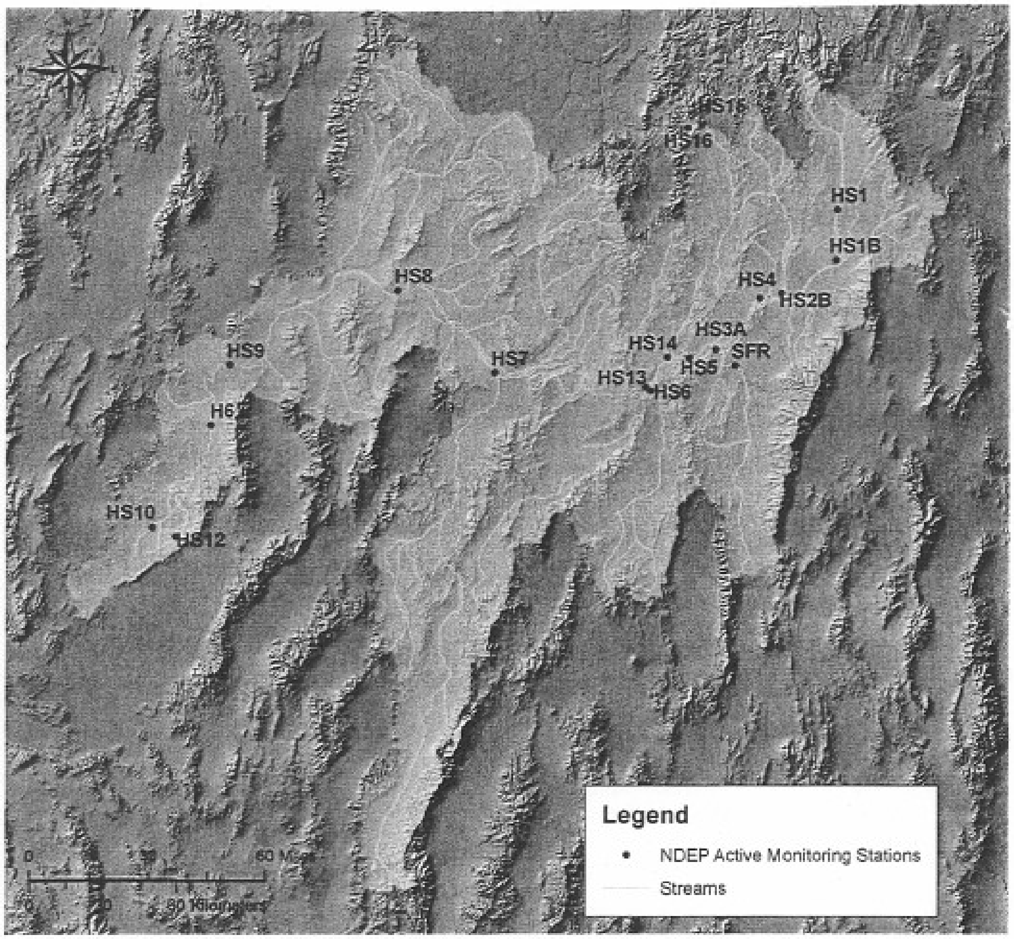

Figure 10 NDEP's active monitoring stations

There are also many other sites listed in the NDEP database. However, many of those sites were sampled very infrequently or do not have the long period of record as those sites on the main stem.

3.4.1 EPA 2004 303(d) list

The monitoring program described above provided most of the data required to compile the 2004 303(d) Impaired Waters List (EPA, 2004). Though the document is not reviewed in full for this study, several relevant points are highlighted below:

- At least 10 water quality samples over a five-year or seven-year period were required before a reach of stream was included on the list, but exceptions were made for datasets with many exceedances.
- Samples were considered representative if they were collected during a variety of flow regimes and seasons.
- Adequate documentation on sampling locations was required.
- Data sets with 10% of the samples exceeding the standard were listed.
- Waterbodies that don't meet the minimum data requirements, yet appeared to have potential water quality problems, were included on the List of Waterbodies Warranting Further Investigation.
- Though biological assessment has been performed since 2000, it was not used as a criteria for listing.
- NDEP is re-evaluating the suitability of the existing water quality standards, particularly those for nitrogen, dissolved oxygen, temperature, and pH.
- NDEP recognizes there may be naturally-occurring pollutants in the waterbody, such as phosphorus, arsenic, selenium, and iron.
- NDEP's funding for monitoring and developing TMDLs is limited, a fact that is not anticipated to change.

The 303(d) list of impaired streams in the Humboldt basin is shown below:

Table 4 303(d) list for Humboldt River basin

Waterbody Name	Reach Description	Length (miles)	Associated monitoring stations	Exiting TMDLs	Pollutants of concern	NAC Reference	Class
Humboldt River	Woolsey to Rodgers Dam	13.22		None	TDS Total iron	445A.126	C
Humboldt River	Rodgers Dam to Humboldt Sink	22.77		None	Boron Total iron Molybdenum	445A.127	D
Mary's River	East line of T41, R59E to Humboldt River	53.2	HSB	None	Total Phosphorus	445A.125	B
Mary's River	Entire river	82.5	HSB	None	Zinc Dissolved oxygen	445A.125	B
South Fork Little Humboldt	Elko County Line to North Fork Little Humboldt	18.2		None	Total iron	445A.125	B

Waterbody Name	Reach Description	Length (miles)	Associated monitoring stations	Exiting TMDLs	Pollutants of concern	NAC Reference	Class
Little Humboldt River	Entire Length	53.52		None	Total phosphorus Zinc (dissolved)	445A.126	C
North Fork Humboldt	Source to confluence with Cole Canyon	2.73	Anglo Gold Mule Canyon, Open Pit	None	Selenium	445A.124	A
North Fork Humboldt	Confluence with Sammy Creek to National Forest Boundary	3.5	Anglo Gold, Mule Canyon Open Pit	None	TDS	445A.124	A
Dry Creek	Waste rock to confluence with NF Humboldt	.1	Anglo Gold, Mule Canyon, Open Pit	None	Selenium TDS	445A.124	A
Sammy Creek	Above waste rock	.6	AngloGold Mule Canyon, Open Pit	None	Arsenic Selenium Zinc	445A.124	A
Sammy Creek	Waste rock to confluence with	.6	AngloGold Mule Canyon, Open Pit	None	TDS Zinc	445A.124	A
Water Canyon Creek	Waste rock to confluence with NF Humboldt	.3	AngloGold Mule Canyon	None	Selenium TDS	445A.124	A
North Fork Humboldt River	National Forest Boundary to Humboldt River	84.67	HS15 HS16 HS2B	None	Total iron Temperature Total Phosphorus	445A.125	B
Sheep Creek	Below Jerritt Canyon Project	6	Anglo Gold Jerritt Canyon	None	TDS	445A.125	B
South Fork Humboldt River	Lee to Humboldt River	32.75	HS3A	None	Total iron Total phosphorus	445A.125	B
South Fork Humboldt River	Dixie Creek confluence to Humboldt River	14.93	HS3A	None	Lead Zinc	445A.125	B
Maggie Creek	Confluence with Jack Creek to Humboldt River	28.07	HS14	None	Total phosphorus	445A.125	B

Waterbody Name	Reach Description	Length (miles)	Associated monitoring stations	Exiting TMDLs	Pollutants of concern	NAC Reference	Class
Maggie Creek	Confluence with Jack Creek to Humboldt River	23.4	HS14	None	pH	445A.126	C
Simon Creek	Above confluence with Maggie Creek	1	Newmont Mining Corp.	None	TDS	445A.126	C
Humboldt River	Origin to Osino	66.12	HS4	None	Total iron Total phosphorus Zinc	445A.203	
Humboldt River	Osino to Palisade	64.39	HS6	Total phosphorus, TSS	Total iron Total phosphorus Turbidity Zinc	445A.204	
Humboldt River	Palisade to Battle Mountain	76.5	HS7	Total phosphorus, TSS	Total iron Total Phosphorus TSS Turbidity Zinc	445A.205	
Pine Creek	Upstream of Palisade	15.92	HS7	None	Total iron TDS Total phosphorus TSS Turbidity	445A.205	
Willow Creek	Below Buckhorn Mine	5	HS7 Cominco American, Inc.	None	Dissolved mercury	445A.205	
Humboldt River	Battle Mountain to Comus	81.36	HS8	Total phosphorus TDS TSS	Boron Total iron TDS Total phosphorus TSS Turbidity Zinc	445A.206	

Waterbody Name	Reach Description	Length (miles)	Associated monitoring stations	Exiting TMDLs	Pollutants of concern	NAC Reference	Class
Humboldt River	Comus to Imlay	114.09	HS9	Total Phosphorus TDS TSS	Total iron Molybdenum TDS Total phosphorus TSS Turbidity Zinc	445A.207	
Humboldt River	Imlay to Woolsey	44.2	H6	None	Molybdenum	445A.208	

Class waters are defined in the Nevada Administrative Code. The relevant chapters and descriptions are provided below.

445A. 124: The beneficial uses of class A waters are municipal or domestic supply, or both, with treatment by disinfection only, aquatic life, propagation of wildlife, irrigation, watering of livestock, recreation including contact with the water and recreation not involving contact with the water.

445A.125: The beneficial uses of class B waters are municipal or domestic supply, or both, with treatment by disinfection and filtration only, irrigation, watering of livestock, aquatic life and propagation of wildlife, recreation involving contact with the water, recreation not involving contact with the water, and industrial supply.

445A.126: The beneficial uses of class C waters are municipal or domestic supply, or both, following complete treatment, irrigation, watering of livestock, aquatic life, propagation of wildlife, recreation involving contact with the water, recreation not involving contact with the water, and industrial supply.

445A.127: The beneficial uses of class D waters are recreation not involving contact with the water, aquatic life, propagation of wildlife, irrigation, watering of livestock, and industrial supply except for food processing purposes.

3.4.2 Existing TMDLs

As documented in the 2004 303(d) list, TMDLs are in place for the following Humboldt River reaches: Osino to Palisade, Palisade to Battle Mountain, Battle Mountain to Comus, and Comus to Imlay (or, in general, from Osino to Rye Patch Reservoir) for Total P, TSS, and TDS. In addition to existing TMDLs, the 303(d) list of impaired waterbodies lists pollutants and stressors of concern, or parameters in addition to the TMDL parameters. They are: iron, turbidity, zinc, mercury, boron, molybdenum, selenium, arsenic, temperature, lead, and pH. Of these pollutants of concern, only molybdenum is missing from the parameters in NDEP's routing monitoring network (Table 4). Molybdenum is only listed as a pollutant of concern in the reach of the Humboldt from Imlay to Woolsey.

3.4.3 List of Waterbodies Warranting Further Investigation

This list, included as Appendix C in the 303(d) Impaired Waters List, identifies those reaches in the Humboldt basin with minimal samples but having potential for water quality problems. This list is separate from the 303(d) list and the state is not required to develop TMDLs for these reaches. However, BWQP recognizes the potential for future inclusion of these waters to the 303(d) list and will use this list as a planning tool for future activities.

There are 24 reaches of the Humboldt basin on this list. The list differs from the 303(d) list in the following ways:

- Many more tributaries are included: Sammy Creek, South Fork Reservoir, Reese River, Pine Creek, Willow Creek, Coon Creek, Long Canyon Creek, Licking Creek, Butte Canyon, Galena Canyon, Rochester Canyon Creek, East Fork and West Fork Rock Creek, Trout Creek, Little Cottonwood Creek, and Iron Canyon.
- The source of data that prompted inclusion on the list include: NDEP, AngloGold Corporation, Newmont Mining Corporation, USFS, BLM, Cominco American Inc., and USGS Open File Report 00-459.
- Constituents: Iron, selenium, temperature, pH, total dissolved solids, total phosphorus, metals, pH, dissolved oxygen, e. coli, total suspended solids, turbidity, cyanide, and acid mine drainage. Though many of these constituents are also pollutants of concern on the 303(d) list, their inclusion on the List of Waterbodies Warranting Further Investigation reinforces the need to include them in the final monitoring plan.

The list of waterbodies warranting further investigation will be addressed in the proposed monitoring section below.

3.5. NDEP Bureau of Water Quality Planning Five-Year Plan

There have been extensive discussions with the Bureau of Water Quality Planning (BWQP) regarding the current state of monitoring, TMDLs, beneficial uses, and other aspects of their mission. The BWQP is in the process of finalizing a five-year plan to outline their anticipated efforts and identify future needs. However, they have the foresight to recognize that plans change with priorities, funding, study results, and myriad other factors. Therefore, the plan is "intended to serve as a dynamic document that is revisited and revised as frequently as appropriate (BWQP, 2006)." These discussions and the review of the *draft* plan form the basis for the summary and recommendations to follow.

3.5.1 Re-Assessment of Beneficial Uses

One of BWQP's primary goals is to re-evaluate the beneficial uses for the waters of the state. The BUs currently in place were set in the 1970s and are, in some cases, no longer appropriate. It is the beneficial uses and their associated numeric standards that dictate the inclusion of waters on the 303(d) list and, in turn, dictate future monitoring and TMDL implementation. Therefore, BWQP recognizes that future water quality monitoring and analysis needs to be performed under reasonable and appropriate beneficial uses.

Unfortunately, Clean Water Act regulations often make it difficult to change or eliminate beneficial uses once they are established. BQWP recognizes this fact and is open to discussions about how to best protect our state's water resources while still complying with the Clean Water Act.

The primary beneficial uses for most reaches in the Humboldt basin are Recreation, Aquatic Life, and Domestic Supply. In general, the water quality standards for the basin were established to protect those three beneficial uses.

3.5.2 Re-Assessment of Numeric Standards

Following a re-assessment of beneficial uses will be an investigation of the numeric standards designed to protect those beneficial uses. The numeric standards are intrinsically tied to the beneficial uses and, when the critical beneficial use for a reach changes, the numeric criteria should, as well. As an example, Domestic Supply is one of the primary beneficial uses for much of the Humboldt system, which results in fairly stringent standards--usually in line with drinking water standards. However, the standard to protect drinking water might not be appropriate in areas with little or no population. Removing Domestic Supply from the beneficial uses of a reach may result in another, less-stringent BU as the critical use.

The BWQP intends to solicit input from other state and federal agencies, as well as other stakeholders, before revising the numeric standards. Also, there is currently a nation-wide effort to improve the numeric criteria for various parameters, including nutrients, TSS, temperature, and iron. BWQP intends to be a part of this effort.

In sum, BWQP is taking the first steps to revise their beneficial use assignments and their associated numeric standards. Given that this process will likely take several years, the recommendations in this report will reflect the beneficial uses and standards currently in place. However, as is discussed below, the proposed monitoring plan is flexible enough to accommodate changes.

3.5.3 Bioassessment

There is a nation-wide effort underway to evaluate the benefits of bioassessment as an indicator of overall stream health. The Environmental Protection Agency began a bioassessment and biocriteria program in 1988 as part of their overall effort to maintain the integrity of the Nation's waters. In 1999, the EPA produced the document "Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers" (Barbour, et. al, 1999).

These protocols are "designed to provide basic aquatic life data for water quality management purposes such as problem screening, site ranking, and trend monitoring." In addition, the EPA developed a summary of bioassessment programs for states (USEPA, 2002), whose purpose was "to determine how many states, and in what fashion, were using biological assessments and criteria in water management programs. EPA used the information from that report to evaluate state bioassessment/biocriteria capabilities and their needs for technical support."

BWQP has been performing bioassessment on selected streams since 2000. Their specific focus has been on macroinvertebrate abundance, diversity and physical habitat conditions. Interviews with BWQP revealed that bioassessment will be a major focus in the future. Their draft five-year plan reveals the Humboldt basin will be assessed between July 2007 and June 2008, and between July 2009 and June 2010, continuing every second year.

BWQP has also received an EPA REMAP grant (Regional Environmental Monitoring and Assessment Program) to "evaluate the State's methods and approaches for incorporating statistically valid ecological monitoring data into their environmental decision making (USEPA REMAP Request for Applications, 2006)." To support this program, BWQP will sample several reference sites and probabilistic sites, with a report to follow in 2008. Characterizations will include macroinvertebrates, periphyton, fish, water chemistry, chlorophyll a, sediment chemistry, fish contaminants, and physical habitat measurements.

The EPA's primary on-line resource for bioassessment and biocriteria can be found at http://www.epa.gov/waterscience/biocriteria/.

3.5.4 Proposed Monitoring Schedule

BWQP's plan for monitoring in the Humboldt basin consists of a combination of 'base' and 'full' sampling. Base sites are a subset of the historic sites and will be sampled twice a year over two years, with each season represented once in a two-year period. Full sampling occurs at all historic sites at least four times per year for two to three years. This plan is a compromise between the need to maintain the long-term record of the historic sites and financial reality.

The tentative plan for the Humboldt basin is: For the Upper Humboldt Tributaries, perform full sampling from July 2007 to June 2010, and resume base sample in July 2010. For the Lower Humboldt Tributaries, perform base sampling until June 2008. Perform full sampling from July 2008 to June 2011, and resume base sampling in July 2011. For the Humboldt River Mainstem, perform base sampling until June 2009 and full sampling from July 2009 to June 2012. In general, BWQP will split the Humboldt basin into three main areas and perform three years of full sampling on each, staggered by one year.

3.6. Data Needs and Gaps

3.6.1 Overview

The mission of BWQP is to protect the state's water resources. To accomplish this task, they need access to all existing water quality data. When much of the data is in paper copy, individual CDs containing spreadsheets, other databases, or text files, it is difficult for any agency to compile all relevant data, making it very likely that some of the data already collected and documented will not be used in an analysis. Data that are readily available were collected for this study. As described above, there exist many other data sources, sometimes stored in the same building, that are, for all intents and purposes, inaccessible to BWQP. Therefore, it is imperative that all data, regardless of its originating format, be available to BWQP in an electronic format.

Regarding monitoring needs, the current BWQP monitoring network and schedule is sufficient for the main stem Humboldt River. Given their resources, the 17 active sites provide an adequate representation of the changes in water quality on the main stem. However, BWQP has identified additional reaches of concern (see Appendix C, Table C-1 in 303(d) list), as well as additional parameters to be included in their analyses. These reaches and parameters should be included in future monitoring programs.

A complicating factor to designing a monitoring plan for the future is BWQP's acknowledgment of the need to re-assess both the beneficial uses and the numeric water quality standards for the Humboldt basin. It is difficult to identify data gaps when the data needs may change. Fortunately, a sufficient monitoring plan can be developed that will cover almost all future regulatory scenarios, while minimizing wasted effort.

3.6.2 Guidelines for Monitoring Programs

The following are guidelines for a monitoring program designed to evaluate a water body with a numeric standard:

- Data sets with long periods of record are valuable;
- Large data sets are valuable;
- Data should be collected under various flow regimes and seasons;
- Data collection methods should be documented;
- Data collection methods should be appropriate to the beneficial use. For example, temperature of a grab sample taken back to the lab has no value. Temperature collected in a sunny area could fluctuate wildly and not give the quality of data required;
- Though a standard may exist for one parameter, another parameter may be well-correlated and easier or cheaper to collect. Provisions should be made for substitute parameters (e.g., using turbidity as a surrogate for total suspended solids).

3.6.3 Modifications to Existing Monitoring Program

The existing monitoring program (described above) should continue. The current parameter list adequately covers existing TMDLs and is directed toward the existing 303(d) list, though given the pollutants of concern on the List of Waterbodies Warranting Further Investigation, molybdenum and dissolved oxygen should be added to the list of constituents.

Though the existing monitoring program includes bioassessment, that portion of BWQP's overall program is still in its infancy. The results from the REMAP project, expected in

2008, will provide guidance for future monitoring efforts and will likely be in step with EPA recommendations. For these reasons, it is impossible to recommend changes to these early bioassessment efforts. The current plan will provide a good baseline for future efforts and should not be changed at this time.

3.6.4 Additional Monitoring Sites and Parameters

The List of Waterbodies Warranting Further Investigation (Appendix C in 303(d) plan) provides a good indication of where additional monitoring is needed. Reaches of streams were added to this list because there were enough samples to raise concern, but not enough to justify inclusion to the 303(d) list. Samples were collected from three primary sources: NDEP's regular monitoring network, USGS Open File Report 00-459, and the mines (through data submitted to the BLM).

Because many sites were listed as a result of NDEP's regular monitoring network, all sites should be continued and only molybdenum and dissolved oxygen should be included in the list of analytes.

The mines submit data to the BLM—data that eventually make their way to NDEP—as part of their permits to operate and discharge to streams and ponds. The data submitted to the BLM is the same data the mines are required to submit to NDEP as a condition of their discharge permit. It is assumed that data collection by the mines will continue as a condition of their permits and data will reside primarily in the BLM field offices. Therefore, as discussed above, a complete monitoring program should require that all data be stored in a central, electronic database.

The data presented in the USGS Open File Report (2000) was collected over eight visits between 1995 and 1999. There were 273 surface water samples performed for this study. This data collection effort resulted in the inclusion of six reaches of stream to the List of Waterbodies Warranting Further Investigation. All six sites are listed for metals. Therefore, those six sites should be added to the monitoring network.

The pollutants or stressors of concern on the List of Waterbodies Warranting Further Investigation are iron, selenium, temperature, pH, total dissolved solids, total phosphorus, metals, dissolved oxygen, e. coli, total suspended solids, turbidity, cyanide, and acid mine drainage. Of these already included in BWQP's regular monitoring network, only dissolved oxygen and cyanide are not yet included. Therefore, it is recommended that dissolved oxygen be added to the list of analytes for all sites, and cyanide be added to the site representing Willow Creek below Buckhorn Mine.

In sum, based on the List of Waterbodies Warranting Further Investigation, it is recommended that the following 16 sites be added to NDEP's regular monitoring network: Sammy Creek, South Fork Reservoir, Reese River, Pine Creek, Willow Creek, Coon Creek, Long Canyon Creek, Licking Creek, Butte Canyon, Galena Canyon, Rochester Canyon Creek, East Fork and West Fork Rock Creek, Trout Creek, Little Cottonwood Creek, and Iron Canyon. Also, dissolved oxygen should be added to the parameter list for all sites, and cyanide should be added for Willow Creek.

3.6.5 Re-assessment of Beneficial Uses

The data required by BWQP to re-assess the beneficial uses is outlined in the draft five-year plan. There are three beneficial uses that will receive the most attention: Propagation of Aquatic Life, Municipal and Domestic Water Supply, and Contact Recreation.

For the propagation of aquatic life (both warm water and cold water systems), BWQP plans to recognize the natural and human-caused differences between the systems. To this end, they will likely develop tiered aquatic life uses to improve beneficial use assignments as well as bioassessment indices. As a guideline, they will use the EPA's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish (available online: http://www.epa.gov/owowwtr1/monitoring/rbp/index.html). Data required for the bioassessment can be found in the forms provided in appendix A of the Rapid Bioassessment. In general, the data required are listed below:

- Observation of predominant surrounding land use
- Observation of erosion
- Description of riparian vegetation
- Measurement of stream dimensions and canopy cover
- Observation of presence of large woody debris
- Description of dominant aquatic vegetation
- Measurement of temperature, specific conductance, dissolved oxygen, pH, and tubidity
- Description of substrate
- Narrative description of habitat
- Measurement of periphyton
- Observation and qualitative listing of macroinvertebrates

Because the effort to re-evaluate the propagation of aquatic life is not yet underway, the entire list, with the possible exception of listing of macroinvertebrates, can be considered a data gap.

To re-assess the municipal and domestic water supply and contact recreation beneficial uses, BWQP will first review these uses on waters below Lahontan Reservoir. Based on the results of that analysis, other waters will be examined in the future using lessons learned. BWQP intends to consider the following factors when evaluating beneficial uses: 1) evidence of municipal and domestic supply being an existing use; and 2) evidence that water meets municipal and domestic supply water quality criteria. Waters not falling in these categories may not necessarily be assigned municipal and domestic supply as a beneficial use. The data gap, therefore, is simply reconnaissance of each reach of stream and documentation of the current use and suitability of water to sustain a beneficial use of municipal and domestic supply.

3.6.6 Improve Numeric Water Quality Criteria

The BWQP is in the process of re-evaluating their numeric criteria for a number of constituents. They have revealed that they will likely rely on results of a nation-wide effort to provide guidance to the states. This effort will address applicability of each standard and incorporate recent scientific advances.

In the five-year plan, BWQP highlights four constituents in need of more appropriate water quality criteria. These are nutrients, TSS, temperature, and iron.

In 1998, EPA Region 9 formed a technical assistance group to evaluate numeric criteria. The group has concluded that nutrient concentrations (in particular, the nitrogen and phosphorus species) are poor predictors of the likelihood of impairment. Other factors may be more important, such as: substrate conditions, light, flow, and turbidity. In addition, indicators such as benthic algae density and dissolved oxygen may provide more insight to the overall level of impairment.

BWQP will be evaluating some simple modeling tools to support revised numeric standards. In the meantime, the data gap can be filled to a large extent by collecting the same data outlined in section 3.6.5 above (Re-assessment of Beneficial Uses).

With respect to TSS and turbidity, BWQP's five-year plan states that they will not move forward until the EPA's Office of Water develops and issues its water quality criteria for the states to better manage suspended and bedded sediments. Therefore, there are currently no additional data that should be collected, other than data that is already part of the regular monitoring network.

The BWQP states that Nevada's temperature criteria are not well documented and are in need of review. They are currently evaluating criteria that account for duration, such as using maximum weekly average temperature rather than single values. However, recognizing that research is still being conducted in the appropriateness of temperature standards, the BWQP is waiting for results before modifying their standards. That said, it is recognized that the current method of single-point measurements is inadequate. Therefore, continuous temperature measurement is likely to be incorporated in any future standard and can be collected immediately.

A similar scenario is found for the iron standard. The current standard of 1000 mg/l has been found to sustain healthy aquatic populations in Ohio. Therefore, BWQP is open to revision, but their five-year plan states they will wait until more information is available.

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